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THE POLITICAL LEGACY OF THE INTERNATIONAL GEOPHYSICAL YEAR

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[1] Documents now out of print and not available from the Foreign Affairs Committee or the Government Printing Office.

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FOREWORD

This study examines in detail a specific example of how the world scientific community has worked together in cooperation and good will toward resolving international problems. Its subject is the International Geophysical Year (IGY), the largest and most complex international scientific undertaking ever attempted.

In keeping with the objectives of the series of which it is one part, this study analyzes the contributions made by the IGY in overcoming ideological differences as a means of building bridges between science and diplomacy. More specifically, it attempts to identify and explain the attitudes, behavior patterns, and procedures followed in the IGY as a step toward détente.

Only time will tell of course whether the laudable example set by the IGY represents the major turning point in history claimed by some. Of importance here and now is the message conveyed in this study that indeed international cooperation in science and technology is possible. What remains is for that example to be emulated and extended.

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Clement J. Zablocki,
Chairman, Subcommittee on National Security Policy and Scientific Developments.

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I. INTRODUCTION

Increasingly, science is being blamed for many, if not most, of the world's ills. It is science which has made possible a highly technological world, and it is ever-expanding technology which has led to some of that world's seemingly most intractable problems.[1] Not only do these problems severely tax domestic capabilities at home, they threaten to engulf relations with countries abroad. Seemingly, science and technology have become the genie escaped from the bottle, no longer subject to man's command alone. Rather, the genie seems possessed by a will of its own, increasingly beyond man's control. At the same time, ironically, it appears unlikely that many of today's problems, whether domestic or international, can be solved other than through the application of additional science and technology. Calls by the neo-Luddites[2] to return to the technological womb, while one part of the world attempts to cope with technology's problems and another part still struggles for its fair share of technology's fruits, appear both inhumane and unrealistic. What, then, to do?

This study, in accordance with the objectives of the entire series of which it is one part,[3] is concerned with the role of science and technology in helping to solve (or, conversely, in sharing the responsibility for generating) problems of international affairs. Contributing to these problems is the fact that science has, in relatively quick succession, provided man with the chemical, the atomic, and the hydrogen bomb, with other, more potent bombs waiting next on the horizon. The extent to which these devices are likely to be used remains largely unresolved. Having provided these singularly powerful tools of destruction, has science contributed to that diplomacy upon which avoidance of their use depends? That question reflects the general concern of this study.

In seeking to shed light on the role of science in international affairs, it seems reasonable to examine in some detail the workings of the world scientific community and the way in which its various components interact. Rather than undertake such an examination theoretically, this case study focuses upon one particular international scientific undertaking and seeks to find ways in which the participation of scientists in this activity may have helped contribute to the ultimate resolution of some problems of international concern.

The International Geophysical Year (IGY)[4] was chosen for study because it represents the largest, most complex, and most comprehensive international scientific undertaking thus far conceived and successfully carried out by scientists. Sixty-seven nations participated, represented by 20,000 to 40,000 scientists and as many volunteer observers, manning about 4,000 principal stations and an equal number of secondary stations and sites scattered throughout the world from pole to pole.[5] Estimates of the total expense of the undertaking have been as high as $2 billion, including logistical support. Throughout the 18 months of the activity [6] scientists generated an unprecedented aura of international cooperation and good will as they attacked the scientific problems while largely avoiding the political ones. Their efforts were hailed variously as "a major turning point in history," [7] as opening up "a new era in the history of the human race," [8] and as having been "the single most significant peaceful activity of mankind since the renaissance and the Copernican revolution." [9] In view of these assessments by responsible observers, the IGY was an attractive subject for analysis of possible contributions of science to the conduct of international affairs.

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[1] Current public awareness of technologically induced problems would appear to be sufficiently widespread to require no elaboration here. For a brief discussion of the subject earlier in this series, see: U.S., Congress, House, Committee on Foreign Affairs, Subcommittee on National Security Policy and Scientific Developments, *The Evolution of International Technology*, 91st Cong., 2d sess., December 1970, pp. 5–6.

[2] A term applied to those opposed to technology on value grounds. Opposition to technology is taken as a moral position: economic determinism has been found inadequate to regulate the production and adoption of good technology while restraining the bad, or (according to another view) there are so many technological innovations that society is increasingly incapable of adjusting to them.

[3] For an overview of the series of studies, see: U.S., Congress, House, Committee on Foreign Affairs, Subcommittee on National Security Policy and Scientific Developments, *Toward a New Diplomacy in a Scientific Age*, 91st Cong., 2d sess., April 1970. For a list of studies published to date, see p. ii.

[4] For a list of abbreviations used throughout this study, see app. 1.

Significantly, the IGY took place at a time of considerable international political distrust and hostility, the period of the so-called cold war between the United States and the Soviet Union. It would be naive to suggest that the political tensions of the period had no effect upon the conduct of IGY scientists or their activities, and equally mistaken to suppose that the IGY brought about fundamental changes in the prevailing pattern of confrontation. The influences of such tensions and confrontation upon international cooperation, however, have been discussed in some detail in previous studies of this series.[10] Here, rather, an attempt is made to illuminate the other side of the picture: to show how scientists and political leaders of many countries worked together with a purposefulness and vigor which suggested not only a spirit of adventure and anticipated accomplishment but also, perhaps, a sense of gratitude or relief over the opportunity to cooperate in an undertaking largely removed from the arena of political conflict.

It may be that the IGY, representing as it did an island of relative tranquillity in a sea otherwise lashed by violent political storms, has been overpraised and undercriticized. Certainly those who knew it best were most enthusiastic and lavish in their praise, and no record appears to remain of any significant criticisms of their exuberance and optimism. A considerable but unsuccessful effort was made to find such criticism for the sake of a more balanced account. However, it is not the purpose of the study to dissect the IGY in an attempt to judge what it failed to accomplish. The primary intent is to search for positive contributions the IGY may have made to building bridges between science and diplomacy, and to determine whether the momentum generated by its activities was sufficient to continue thereafter to help translate a variety of international hopes and plans into concrete realities.

Too much should not, of course, be read into the apparent détente reflected in this one scientific enterprise, and assessment of its effects on world diplomacy must be tempered by the recognition that many other factors were at work both for and against international amity. Sorting out and weighing the particular impacts and consequences of the IGY would be a manifest impossibility. Nevertheless, it is possible to identify specific attitudes, behavior patterns, and rules of procedure that are consistent with or even promote détente. Without overstating the case, the study attempts to highlight these factors.

The first part of this analysis provides background information on the IGY, including its antecedents, origin, and evolution, and organization and funding. The scientific program is described in section III; the scientific results are discussed in section IV. The political impacts are considered in section V, including both general effects and those specific effects due primarily to the Soviet IGY artificial satellite program. In section VI some general comments are made concerning the possibility of applying the international goodwill generated by the world scientific community to the solution of international political problems. Finally, some specific examples are given of the influence of the IGY upon subsequent international diplomacy.

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[5] U.S., Congress, House, Committee on Appropriations, *National Science Foundation, National Academy of Sciences, Hearings; Report on the International Geophysical Year*, 86th Cong., 1st sess., February 1959, p. 6. Subsequently referred to as *NSF-NAS Hearings; IGY Report*. From the statement of Dr. Joseph Kaplan, Chairman of the U.S. National Committee for the IGY. The 67 nations were: Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Bulgaria, Burma, Canada, Ceylon, Chile, Colombia, Cuba, Czechoslovakia, Denmark, Dominican Republic, East Africa, Ecuador, Egypt, Ethiopia, Finland, France, German Democratic Republic, German Federal Republic, Ghana, Greece, Guatemala, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, Jugoslavia, Korea (Democratic People's Republic), Malaya, Mexico, Mongolian People's Republic, Morocco, Netherlands, New Zealand, Norway, Pakistan, Panama, Peru, Philippines, Poland, Portugal, Rhodesia and Nyasaland, Romania, Spain, Sweden, Switzerland, Taiwan (Academia Sinica), Thailand, Tunisia, Union of South Africa, Union of Soviet Socialist Republics, United Kingdom, United States of America, Uruguay, Venezuela, Vietnam (Democratic Republic), and Vietnam (Republic). (A committee formed by the People's Republic of China in September 1955 withdrew in June 1957).

[6] The year actually encompassed 18 months, rather than the calendar 12 months, to accommodate the full period of estimated maximum solar activity.

[7] Walter Sullivan, *Assault on the Unknown; The International Geophysical Year* (New York: McGraw-Hill Book Co., 1961), p. 415.

[8] Sidney Chapman, *IGY; Year of Discovery, The Story of the International Geophysical Year* (Ann Arbor: The University of Michigan Press, 1959), p. 107.

[9] *NSF-NAS Hearings; IGY Report*, p. 17. From the statement of Dr. Hugh Odishaw, Executive Director of the U.S. National Committee for the IGY.

[10] See, in particular, the following: Lenice N. Wu, *The Baruch Plan; U.S. Diplomacy Enters the Nuclear Age* (August 1972) and Warren H. Donnelly, *Commercial Nuclear Power in Europe; The Interaction of American Diplomacy with a New Technology* (December 1972). U.S., Congress, House, Committee on Foreign Affairs, Subcommittee on National Security Policy and Scientific Developments, 92d Congress, 2d sess. (Washington: U.S. Government Printing Office).

II. Background of the IGY (1957–58)

The IGY has been called "perhaps the most ambitious and at the same time the most successful cooperative enterprise ever undertaken by man." [11] This assessment was voiced by the late Lloyd V. Berkner, originator of the proposal which ultimately led to the IGY, and Vice President of the international body which coordinated all IGY activities.[12] Yet this remarkable effort might never have taken place had it not been preceded by a history of growing international scientific cooperation from ancient times to the present day.

Antecedents of the IGY

Scientific cooperation appears evident even in ancient times, when travelers exchanged information needed to develop maps for their mutual use.[13] Francis Bacon, early in the 17th century, proposed cooperative efforts as the best way of obtaining information about the nature of the world. Such efforts as did take place, however, were undoubtedly more a matter of happenstance and chance than of premeditated planning. Not until the 18th century did coordinated efforts by many men at many points become more common. Observations of the transit of Venus in 1761 represented an early attempt at a concerted international effort, largely by European nations. In 1769 a subsequent transit of Venus, some portions of which were visible in the American colonies, afforded the opportunity on the part of the New World to link scientific observations with the Old.

For the most part, these initial early cooperative efforts were independently conceived and only poorly coordinated. During the 19th century, international efforts intensified and close coordination became more common. Largely as a result of efforts by a group of French scientists, a network of weather observation stations was established, data first being published in 1800. To facilitate coordinated weather observations at sea as well as ashore, an international conference in Brussels in 1853 decided that warships of the participating nations would utilize standard forms for data-taking, and the information would be distributed to all. This effort moved Matthew F. Maury, an American naval officer who had initially proposed such cooperation, to comment:

> Rarely before has there been such a sublime spectacle presented to the scientific world: all nations agreeing to unite and cooperate in carrying out one system of philosophical research with regard to the sea. Though they may be enemies in all else, here they are to be friends.[14]

The need to learn more about the earth's magnetism, as well as its weather, led to other international cooperative efforts during the 19th century. Worldwide magnetic observations were carried out from Peking, China, to Sitka, Alaska, and an international magnetic union was established to fix, in advance, specific days for the simultaneous recording of data. Increased cooperation led rapidly to the formation of other international scientific organizations, including the International Association of Geodesy (1864), the International Bureau of Weights and Measures (1875), and the International Meteorological Organization (1878). The most direct antecedents of the IGY, however, were the First and Second International Polar Years, which to some extent may be considered models for the IGY.

THE FIRST INTERNATIONAL POLAR YEAR (1882-83)

The First International Polar Year (FPY), which took place in 1882–83, has been called the grandfather of the IGY. During this period, scientists from 20 nations carried out cooperative efforts in the high northern latitudes, placing primary emphasis upon studies of surface meteorology, geomagnetism, and the aurora borealis.[15] Although no fundamental discoveries resulted from these studies, many valuable data were obtained in many fields, including those of the aurora, geology, geomagnetism, earth currents, meteorology, glaciology, oceanography, and latitude and longitude.[16] The success of these efforts led, 50 years later, to the much larger effort of the Second International Polar Year.

THE SECOND INTERNATIONAL POLAR YEAR (1932-33)

Although the primary emphasis of the Second International Polar Year (SPY), which took place in 1932–33, was also on studies of the weather, the earth's magnetism, and the aurora, the program also included studies of earth-sun relationships and of atmospheric electricity. Scientists from 40 countries participated,[17] publishing analyses and observations in the fields of meteorology, radiation, ozone, aerology, geomagnetism, earth currents, atmospheric electricity, ionospheric physics, auroral physics, cosmic rays, hydrography, glaciology, noctilucent clouds, nacreous clouds, biology, and astronomy.[18] Substantial progress was achieved toward understanding magnetic storms and other magnetic disturbances, associated auroral and ionospheric phenomena, and wind and pressure systems in high latitudes of the Northern Hemisphere.[19] Perhaps the most important result of the SPY, however, was increased knowledge of the ionosphere, which greatly advanced the science of radio communications.[20]

Origin and Evolution of the IGY [21]

The success of the SPY, following the FPY by exactly 50 years, raised expectations that a Third International Polar (TPY) would be held at an interval of another 50 years, or during 1982–83. However, the accelerating pace of technological achievement was generating a need for more frequent international efforts. By 1950, at least three compelling reasons for reducing the time interval between "polar years" had evolved: (1) existing basic scientific data in the earth sciences had been largely exploited, making desirable the accumulation of new data; (2) the need for new information regarding the earth, the oceans, and the upper atmosphere was becoming critical with the development of supersonic aircraft and new communications systems; and (3) a period of unusual solar activity was predicted for 1957–58, thereby offering an unparalleled opportunity for observing solar phenomena.

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[11] J. Tuzo Wilson, *IGY; The Year of the New Moons* (New York: Alfred A. Knopf, 1961), p. vii.

[12] This group was known as the Bureau du Comité Spécial de l'Année Géophysique Internationale, or CSAGI.

[13] Much of the following material has been summarized from Sullivan, *Assault*, pp. 4–19.

[14] Matthew F. Maury, *The Physical Geography of the Sea* (New York: Harper Bros., 1855), p. xiii. Maury, known as the Pathfinder of the Seas for his researches of ocean currents following an injury that incapacitated him for sea duty, joined the Confederacy during the Civil War and became its foremost naval officer.

[15] Allen V. Astin, "The Scientific Community and International Cooperation," *Department of State Bulletin* 61 (July 14, 1969), p. 34.

[16] N. C. Gerson, "From Polar Years to IGY," *Advances in Geophysics* 5 (1958), p. 43.

[17] Astin, "The Scientific Community," p. 34.

[18] Gerson, "Polar Years," p. 44.

[19] Elliott Roberts, "The IGY in Retrospect," *Annual Report of the Board of Regents of the Smithsonian Institution*, Publication 4392 (Washington: U.S. Government Printing Office, 1960), p. 265.

[20] National Academy of Sciences, *Report on the U.S. Program for the International Geophysical Year* (Washington: National Academy of Sciences-National Research Council, 1965), p. 50–v. Subsequently referred to as *NSF IGY Program Report*.

[21] A brief chronology of the IGY is given in app. 2.

IMPETUS FOR A THIRD INTERNATIONAL POLAR YEAR

It was therefore suggested by Berkner that a Third International Polar Year (TPY) be held during 1957–1958, only 25 years after the SPY, rather than the anticipated 50 years. The suggestion, which was made at a small gathering of scientists at the home of Dr. James A. Van Allen, was enthusiastically welcomed by Van Allen and his guests, who suggested that Berkner should present his idea at the next meeting of the Joint Commission on the Ionosphere (MCI).[22] Following this suggestion, the basic concept of the TPY was presented to a number of international scientific organizations which readily supported and promoted the idea. A schematic representation of the progress of the concept through the world scientific community is given in figure 1. Initially, as suggested at the Van Allen meeting, Berkner and Dr. Sydney Chapman, who later was to serve as president of the governing IGY committee, presented the concept at the Brussels meeting of the MCI in July 1950. The MCI endorsed the proposal, amplified the suggested program somewhat, and recommended the project to the International Council of Scientific Unions (ICSU), and the three groups comprising ICSU: the International Union of Scientific Radio (URSI),[23] the International Union of Geodesy and Geophysics (IUGG), and the International Astronomical Union (IAU). The URSI and IAU officially endorsed the plan in September 1950, and the IUGG followed with its endorsement in August 1951. The ICSU Bureau, the executive body responsible for operations of ICSU, approved the plan in January 1951 and recommended it to the ICSU executive board, which granted its approval in October 1951. On May 16, 1952, the ICSU established a committee to take charge of the program, which was still being considered primarily as a Third Polar Year.

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[22] Sometimes referred to as the Mixed Commission on the Ionosphere.

[23] The initials are derived from the French version of its name: the Union Radio-Scientifique Internationale.

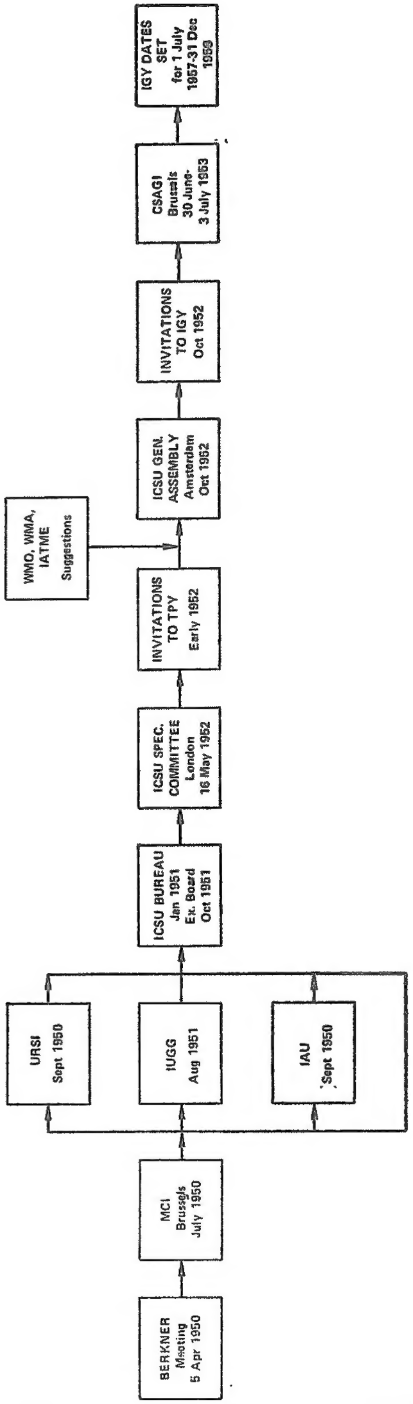

FIGURE 1. Evolution of the Concept of the IGY.

Early in 1952, invitations to participate were sent to member nations of the ICSU, as well as to the U.S.S.R., which was not an ICSU member.[24] The response to this initial solicitation was modest, largely because many of the national academies were not greatly interested in participating in a polar scientific activity. Several international organizations, particularly the World Meteorological Organization (WMO), the International Meteorological Association, and the International Association of Terrestrial Magnetism and Electricity, took the position that the TPY program placed too much emphasis upon the polar regions and, instead, should be expanded to encompass worldwide phenomena.

The ICSU considered these suggestions for enlarging the scope of the TPY, and Dr. Chapman proposed that the suggestions be adopted with the name of the program changed to the International Geophysical Year. This change in name and scope was approved by the ICSU general assembly in October 1952, to reflect the need for worldwide synoptic observation and analysis. Followup notices, sent to ICSU member countries and calling for participation in the IGY, resulted in a much better response than had the initial invitation for a TPY. One result of the improved response was that the original special ICSU committee was enlarged and, early in July 1953, was renamed the Comité Spécial de l' Année Géophysique Internationale, or CSAGI. At this time, Dr. Chapman was named president of the CSAGI and Berkner vice president. One of the first decisions made by the CSAGI was that the IGY would continue for 18 months, from July 1, 1957, to December 31, 1958, so as to include the entire period of anticipated maximum solar activity.

THE SCIENTIFIC RESPONSE

The concept of an IGY, as opposed to a TPY, gained immediate and widespread acceptance throughout the world scientific community. Following the initial provisional meeting of the CSAGI in October 1952, five additional meetings were held, as listed in table 1, below:

TABLE 1. PLENARY MEETINGS OF THE CSAGI

	Location	Date	Year
First	Brussels	June 30–July 3	1953
Second	Rome	Sept. 30–Oct. 4	1954
Third	Brussels	Sept. 8–14	1955
Fourth	Barcelona	Sept. 10–15	1956
Fifth	Moscow	July 29–Aug. 9	1958

At the first meeting, 26 nations participated; at the second, 38 nations; at the fourth, 51 nations; and by the final meeting, 67 nations were represented.

The general spirit of the scientific community was summarized by Berkner as follows:

> But most encouraging in all has been the genuine enthusiasm with which the scientists of the earth, and the nations that support them, have embraced this program. Tired of war and dissension, men of all nations have turned to "Mother Earth" for a common effort on which all find it easy to agree.[25]

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[24] Although not a member of the ICSU, the U.S.S.R. was a member of the IAU and also of the World Meteorological Organization (WMO). Inasmuch as Soviet participation in any large-scale international scientific undertaking was important to the success of that event, the Soviets were also approached through the IAU and WMO.

[25] Lloyd V. Berkner, "International Scientific Action: The International Geophysical Year, 1957–58," *Science* 119 (Apr. 30, 1954), p. 575.

THE POLITICAL RESPONSE

Interest in the IGY was not confined to the world scientific community, but was shared by the various governments concerned, by heads of state, and by the public at large. This interest was aroused by the strong appeal of the IGY as a cooperative venture representing many nations working together for the benefit of all mankind. Consequently, the collective response of the many legislative bodies and governments whose approval was necessary to make the program a success was on a far more generous scale than that prompted by any previous international scientific enterprise.

Governmental support consisted not only of unprecedented financial contributions, but also of equally valuable and necessary logistic support. Governments cooperated by facilitating the movement of participating scientists from one country to another, and in assuring prompt movement through customs of scientific equipment upon which the various programs depended. President Eisenhower, in a White House press release on June 25, 1954, called the IGY "a striking example of the opportunities which exist for cooperative action among the peoples of the world."[26] Pope Pius XII commended the effort as one likely to contribute to peace and cooperation among all people and to their material well-being.[27] Widespread interest in the IGY was aroused in the general public by numerous articles in the daily press and in popular magazines. Consequently, more was undoubtedly known concerning the IGY than had been the case for any previous international scientific effort, and expectations were correspondingly raised.

Although it would seem unlikely that no voices were raised in protest concerning an effort of this cost and magnitude, such expressions do not appear to have survived the passage of time. Virtually no criticism of the IGY exists throughout the vast quantity of published material concerning it. Congressional debate on the IGY during the period 1954–59 was almost devoid of criticism. Similarly, appropriations hearings and committee reports accompanying appropriations bills did not criticize the scientific intent of the effort, but were largely limited to discussions of the reliability of cost estimates made by scientists. Thus the question was never "whether" but "how much," as discussed later.[28]

Organization and Funding of the IGY

One of the outstanding features that characterized the IGY was the relative smoothness and efficiency with which its governing apparatus functioned despite the enormous size of the effort. Partly, this success was due to the utilization by the scientific community of existing organizations and institutions wherever feasible. Of perhaps even greater significance, however, was the ability on the part of the IGY leadership to structure the undertaking so as to maintain as sharp as possible a demarkation between international concerns, on the one hand, and more purely national concerns on the other. This separation was instrumental in reducing both the number and the intensity of the inevitable nationalistic issues which, if permitted to ferment and grow, could have undercut and arrested the growth of the international scientific program. The way in which the IGY was organized largely prevented national political concerns from unduly interfering with international scientific objectives.

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[26] U.S. President (Eisenhower), "Letter to Dr. Chester I. Barnard, Chairman, National Science Board, Concerning United States Participation in the International Geophysical Year. June 25, 1954." In: *Public Papers of the Presidents of the United States. Dwight D. Eisenhower* (Washington: U.S. Government Printing Office, 1954), p. 598.

[27] Sidney Chapman, "The International Geophysical Year, 1957–58," *Nature* 175 (Jan. 8, 1955), p. 56. A summary of the Pope's remarks, as translated from the French by Lloyd Berkner, appears in U.S., Congress, House, Committee on Appropriations, *Independent Offices Appropriations for 1956, Hearings*, 84th Cong., 1st sess., Feb. 9, 1955, p. 343. Subsequently referred to as House, *Independent Offices Appropriations for 1956.*

[28] For Congressional debates on the IGY, see the following in the *Congressional Record:* Vol. 100, pp. 10932, 11462–11464, 14807 (1954); vol. 101, pp. 4055, 4068, 7629 (1955); vol. 102, pp. 5267, 6209, 8358 (1956), and vol. 104, pp. 14643, 17535 (1958).

INTERNATIONAL ORGANIZATION AND FUNDING

Both international organization and funding of the IGY were under the general oversight of the ICSU, a federation of several international and scientific unions. Although independent and not directly linked with any nation, the ICSU was organizationally linked to national Governments through their national academies and through the United Nations Educational, Scientific, and Cultural Organization (UNESCO), as shown schematically in figure 2. This existing arrangement provided a convenient, efficient mechanism development of the IGY, which probably would never have been initiated without the influence of the ICSU and its member unions.

The chief governing body for all IGY activities was the CSAGI, which was established by the ICSU for that purpose. The status and functions of the CSAGI were specifically international. As originally constituted, the so-called Bureau of the CSAGI consisted of three people representing the ICSU: Sidney Chapman, President (United Kingdom), Lloyd V. Berkner, Vice President (United States), and M. Nicolet, Secretary General (Belgium). This group, or Bureau, was subsequently expanded to include V. V. Beloussov (U.S.S.R.) and J. Coulomb (France), both members of the IUGG, so as to include representation from the four major powers: the United States, the United Kingdom, the U.S.S.R., and France. Gradually the CSAGI was enlarged to include additional members of various international unions, organizations, and committees until there were 24 members in all. In keeping with the nonnationalistic character of the CSAGI, little attempt was made to have the representation correspond in any way to the IGY efforts of the individual nations.[29]

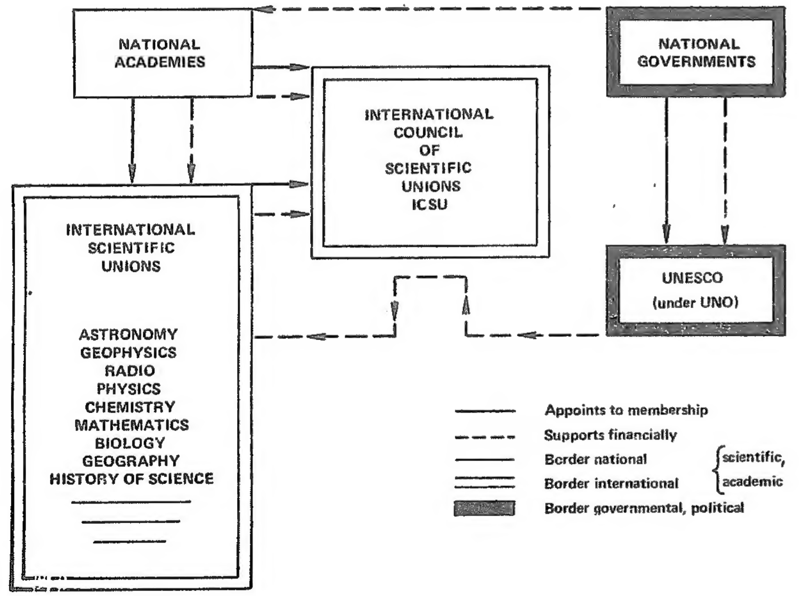

FIGURE 2. International Organization of Science (not including medical or agriculture). Taken from: Sidney Chapman, "International Cooperation and the IGY," *Bulletin of the Atomic Scientists* 16 (May 1960), p. 174.

Thus, the composition of CSAGI was based upon the relative effort being expended in the various scientific areas, and to some extent upon the physical location of CSAGI, rather than upon the magnitude and cost of the scientific programs of individual participating nations. This arrangement was sometimes questioned by members of Congress who felt that, in view of the relatively large costs of the U.S. program, more American scientists should have been members of CSAGI. The scientists pointed out that such representation had no political significance or importance and was unrelated to the cost of the various IGY programs, which were national whereas CSAGI was international. This international concept was essential in order to preserve the completely nonpolitical character of CSAGI, a factor which proved to be vital in preventing nationalistic issues from interfering with IGY scientific activities.

It was evident early in the IGY preparations, however, that a need existed for bringing national problems before the IGY for solution, since many activities required coordination between the national committees of participating nations. A formal means was also needed to enable the national committees collectively to discuss and express their views on IGY matters. Such local matters as one nation's assisting another with funds, equipment, or personnel, or permitting workers to carry out or cooperate with assignments on foreign territory, could not be dealt with by CSAGI. Hence, CSAGI recommended that ICSU form an advisory council for the IGY composed of one delegate from each national committee, but not to include members of CSAGI.

The Advisory Council was thereby established, and proceeded to deal with problems of a largely national character, usually after such problems had been considered first by representatives of the particular nations concerned. The Advisory Council, made up of representatives of all the nations participating in the IGY, advised and assisted the much smaller CSAGI. The main areas of Council responsibility were: (1) To arrange for mutual assistance between and among nations, (2) to arrange regional meetings on specific subjects, and (3) to allocate responsibility to various nations for storing IGY data. The Advisory Council, which met in parallel sessions during each plenary session of CSAGI, became highly influential and added much strength to the central organization. The presence of designated official delegates from IGY nations made it easier to arrange bilateral mutual assistance, like establishment by one national committee of operations on another committee's territory.[30] These were the kinds of arrangements which

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[29] Sidney Chapman, "International Cooperation and the IGY," *Bulletin of the Atomic Scientists 16* (May 1960), p. 174.

[30] Chapman, "International Cooperation," p. 175.

CSAGI itself expressly avoided. The general organizational arrangement is shown in Figure 3.

The separate existence of CSAGI, on the international level, and the Advisory Council, on the national level, has been considered the key element in the efficient and effective functioning of the IGY. Scientists of each participating country devised their own research programs within their own national committees, and the output of these committees then served as the input for the Advisory Council. The IGY was thus an international scientific enterprise, operated by scientists with the consent, cooperation, and support of their individual governments, but in effect without the direction of these governments.[31]

This dual organizational structure—CSAGI and international scientific bodies, vis-a-vis the Advisory Council and national IGY committees—was considered by many observers to be the major reason why the IGY was so generously funded. Berkner, for example, pointed out that various national governments responded favorably to requests for money and support because the actual work was directed and carried out by national committees rather than by an international body.[32] In testimony before congressional appropriations hearing, considerable emphasis was placed by scientists upon the fact that the IGY program was "preeminently national in character and scope."[33] Dr. Alan T. Waterman, at that time Director of the National Science Foundation, stated that—

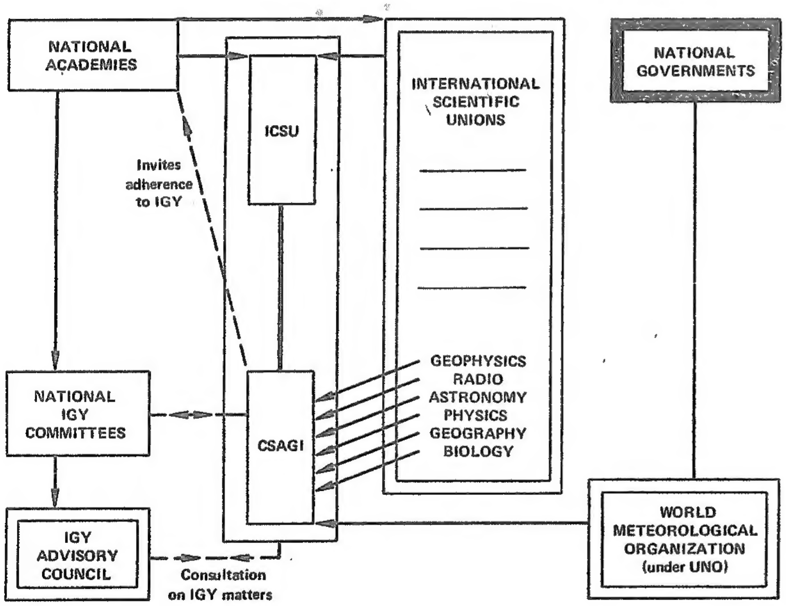

FIGURE 3. The IGY Constitution and Associations of the ICSU Special IGY Committee, CSAGI. Taken from: Sidney Chapman, "International Cooperation and the IGY," *Bulletin of the Atomic Scientists* 16 (May 1960), p. 174. (Key: as in Figure 2.)

> . . . this Geophysical Year is entirely handled by this country; it is not an internationally pooled effort; the United States has its own program, in keeping with the general plan under which all the nations are participating.[34]

Only a relatively small proportion of IGY funds was spent to finance the international IGY organization: somewhat more than one quarter of a million dollars out of an estimated total expenditure of approximately $2 billion, or slightly more than about 0.01 percent.[35] General operating funds were obtained from a number of different sources, as shown in figure 4. Most of these funds were obtained from national and international members of the ICSU, special contributions from participating members and foundations, and from UNESCO. One indication of the popularity of the IGY with national governments was that funding requests by the ICSU were oversubscribed, thus permitting a substantial balance to be carried forward to assist in post-IGY publication of scientific results.[36]

U.S. ORGANIZATION AND FUNDING

Different countries approached the problem of gaining and administering funds in different ways. In the United States, a National Committee for the IGY (the USNC) was established by the National Academy of Sciences, which was a member of ICSU.[37] The USNC served as a focus for all U.S. technical panels, geographical committees, and special groups, as well as for a broad cross section of leading American geophysicists. The USNC provided technical guidance for the National Science Foundation, which was responsible for preparation of budget estimates and for obtaining congressional appropriations. Originally questions were raised as to whether NSF possessed the necessary authority to participate in the IGY, but these questions were resolved satisfactorily.[38]

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[31] Lloyd V. Berkner, "Geography and Space," *The Geographical Review* 49 (July 1969), p. 313. The budget for the U.S. IGY program, of course, was carefully scrutinized by the appropriate congressional appropriations committees and justification for each element of the program was required on a line-item basis. In no instance, however, was a suggestion made for reducing or expanding any particular element in the program.

[32] Statement to the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, Sept. 12, 1958, p. 13.

[33] Testimony of Dr. Alan T. Waterman in: U.S., Congress, House, Committee on Appropriations, *The Supplemental Appropriation Bill, 1955, Hearings, Pt. 2,* 83d Cong., 2d sess., Apr. 27, 1954, p. 901. Subsequently referred to as: House, *Supplemental Appropriation Bill, 1955.*

[34] Testimony in: U.S., Congress, Senate, Committee on Appropriations, *The Supplemental Appropriation Bill, 1955, Hearings on H.R. 9936,* 83d Cong., 2d sess., Apr. 28, 1954, p. 551. Subsequently referred to as: Senate, *Hearings on H.R. 9936.*

[35] Sidney Chapman, "The International Geophysical Year," *AGU Transactions XL* (June 1959), p. 118. The chief contributors, and the approximate amounts contributed over the period 1955–61, were: the United States, $75,000; the Soviet Union, $45,000; Great Britain, $21,000; and Canada, $10,000. In addition, UNESCO gave $85,000 and the ICSU, $40,000.

[36] Wallace W. Atwood, Jr., "The International Geophysical Year in Retrospect," *Department of State Bulletin* 40 (May 11, 1959), p. 684.

[37] A detailed, comprehensive description of U.S. organization and funding is given in *NAS IGY Program Report*, pp. 896–900.

[38] House, *Supplemental Appropriation Bill, 1955*, p. 937.

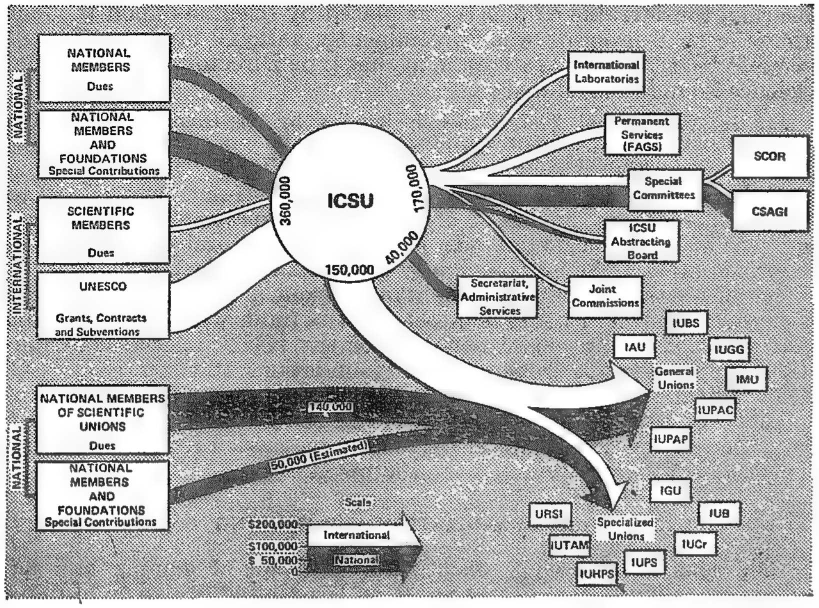

FIGURE 4. Schematic Flow Chart for International Funding of the IGY. Taken from: Wallace W. Atwood, Jr., "The International Geophysical Year in Retrospect," *Department of State Bulletin* 40 (May 11, 1959), p. 685.

The original budget presented to the Congress for the IGY was for $13 million. Dr. Waterman emphasized that this budget was "entirely separate and distinct from the regular programs of the National Science Foundation," [39] a fact of considerable importance inasmuch as the entire NSF budget at that time was of similar magnitude.[40] Later, a considerably greater budget of $40 million for an expanded IGY program was presented.[41] In all, $43.5 million was appropriated by the Congress in support of the U.S. scientific program for the IGY, as shown in table 2.

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[39] House, *Supplemental Appropriation Bill, 1955*, p. 901.

[40] The 1955 NSF budget was $12.486 thousand, and the 1956 budget was $16.068 thousand. See: U.S., Congress, House, Committee on Science and Astronautics, Subcommittee on Science, Research, and Development, *The National Science Foundation; A General Review of Its First 15 years*, 89th Cong., 2d sess., Jan. 24, 1966, pp. 32–35.

[41] For details of this expanded program, see U.S., Congress, House, Committee on Appropriations, *Second Supplemental Appropriation Bill, 1956, Hearings*, 84th Cong., 2d sess., Mar. 8, 1956, pp. 427–440. Subsequently referred to as: House, *Second Supplemental Appropriation Bill, 1956*.

TABLE 2. CONGRESSIONAL APPROPRIATIONS FOR THE IGY [43]

	Appropriated	Obligations	Unobligated [1]
Fiscal year—			
1955	$2,000,000	$1,836,542	$163,458
1956	37,000,000	14,904,593	22,172,936
1957		15,036,898	17,337,064
1958	2,000,000	19,337,064	
1959	2,500,000	5,932,004	1,707,589
1960		1,597,585	110,004
1961		20,429	36,629
1962		88	39,717

[1] Financial reports of the National Science Foundation.

TABLE 3. CONGRESSIONAL APPROPRIATIONS FOR THE IGY BY INDIVIDUAL SCIENTIFIC AREA [43]

Program	Amount
Aurora and airglow	$1,718,022
Cosmic rays	1,164,812
Geomagnetism	1,580,894
Glaciology	1,137,905
Gravity	505,289
Ionospheric physics	3,237,816
Longitudes and latitudes	24,100
Meteorology	2,226,800
Oceanography	2,007,054
Rocketry	2,598,952
Seismology	877,049
Solar activity	307,378
World days	229,050
Interdisciplinary research	1,750,526
Earth satellites	19,843,210
World data center	1,513,587
General scientific support	1,076,551
Technical direction	1,377,266
Total	43,176,261

Almost half of this money was spent in support of the IGY earth satellite program, as shown in table 3. However, as pointed out by Hugh Odishaw, Executive Director of the U.S. National Committee, these apprpriated funds represented only about one-third of the total U.S. research effort: another third resulted from contributions from private institutions (particularly universities), with the remaining third being provided through already existing programs in both public and private laboratories.[44] Other Government agencies providing support for the USNC included the Department of Defense, the State Department, the Commerce Department, the Atomic Energy Commission, and the Office of Defense Mobilization.[45] The Navy, for example, initially estimated its support for the Antarctic IGY pro-

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[42] U.S., Congress, House, Committee on Science and Astronautics, Subcommittee on Science, Research and Development, *The National Science Foundation; A General Review of Its First 15 Years*, 89th Cong. 2d sess., H. Rept. No. 1219, Jan. 24, 1966, p. 77.

[43] *Report on the U.S. Program for the International Geophysical Year* (Washington: National Academy of Sciences-National Research Council, November 1966), p. 897.

[44] Hugh Odishaw, "The Meaning of the International Geophysical Year." In: *NSF-NAS Hearings; IGY Report*, p. 20.

[45] House, *Supplemental Appropriation Bill, 1955*, pp. 901, 923.

gram to be almost $30 million.[46] Eventually the logistical and operational support for IGY activities increased the U.S. outlay to approximately $500 million.[47]

Although both Houses of Congress supported IGY requests enthusiastically, the House frequently reduced the amounts requested whereas the Senate usually voted for the full amounts. The final figures arrived at represented a compromise between the two bodies.[48] Action in the House reflected a belief that the budget estimates arrived at by the scientists were necessarily rough and could be reduced without damage to the U.S. IGY program, whereas the scientists insisted that the budget estimates were conservative and that any reductions would indeed severely damage the program.[49] Irritation was also expressed in the House that the scientists were making use of administration prestige to "sell" the IGY program, thereby relegating the Congress to a back seat in the endeavor.[50] These difficulties were relatively minor, however, and for the most part the Congress granted the scientists what they requested.

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[46] House, *Second Supplemental Appropriation Bill, 1956*, p. 523.

[47] Much of this support was provided for two major areas: Antarctic research, and rocket and satellite activities. This estimate is very rough, however, and represents a best estimate by those having an intimate knowledge of the U.S. program. It includes not only explicit expenses, but also such expenses as the salaries of scientists on loan at full pay from their respective institutions.

[48] See these House and Senate reports: H. Rept. 2266 (July 16, 1954), 304 (Mar. 26, 1955), 1897 (Mar. 15, 1956), and 2221 (July 18, 1958); and S. Rept. 2034 (July 31, 1954), 411 (June 2, 1955), 1725 (Apr. 11, 1956), and 2350 (Aug. 13, 1958).

[49] See, for example: U.S., Congress, Senate, Committee on Appropriations, *Independent Offices Appropriations for 1956, Hearings on H.R. 5240*, 84th Cong., 1st sess., Apr. 25, 1955, pp. 441–443. Subsequently referred to as: Senate, *Hearing on H.R. 5240*.

[50] House, *Second Supplemental Appropriation Bill, 1956*, pp. 440–442.

III. The Scientific Program

The scientific program proposed for the IGY was both ambitious and complex. Having agreed upon the scientific rationale for the undertaking, however, scientists quickly organized and implemented the program, subject only to several seemingly unavoidable—but not overly restrictive—political constraints.

The Scientific Rationale

The scientific rationale for undertaking the IGY 25 years sooner than had been anticipated was based upon a number of factors. First, since the world's scientific "storehouse" of data concerning man's physical environment was considered largely exhausted, it was maintained that the scientific community could not wait until 1982 (50 years after the SPY) to replenish this storehouse.[51] In particular, many scientists considered that further progress in the geophysical sciences was being hampered by lack of information that could only be obtained by a coordinated, worldwide cooperative data-taking venture.

Second, soon after the SPY there had been an unprecedented development of new research tools in the geophysical sciences. These included radiosonde balloons capable of investigating 90 percent of the earth's atmosphere, and rockets (developed during World War II) capable of investigating the remaining upper 10 percent, as well as the fringes of outer space. New cosmic ray recorders, spectroscopes, and other instruments were available to permit in-depth investigation of the nature and composition of the aurora, the newly-discovered "air-glow", the sun and its corona, and the earth's magnetic field. Furthermore, electronic computers had sufficiently evolved to enable efficient handling of the vast amounts of data that a massive worldwide scientific effort would generate.

Third, geophysicists had become increasingly fascinated by the earth's remote polar areas. The Arctic was of great interest from the standpoint of radio communications and weather forecasting. The Antarctic remained the largest unexplored landmass on the earth's surface. With scientists encircling the globe in unprecedented numbers, the IGY offered an excellent opportunity for obtaining information regarding these remote polar regions.

Fourth, and finally, a period of intense solar activity had been predicted for 1957–58. The actual 18-month period finally chosen for the IGY represented an attempt to span, as completely as possible, the anticipated period of maximum sunspots so that the effect of solar storms upon the earth could be investigated. Such storms were particularly interesting to the scientific community because sunspot activity had been at a minimum during the SPY. This prediction of high solar activity turned out to be gratifyingly accurate: sunspot fluctuations during the IGY reached the greatest intensity ever recorded since scientists first began to observe such phenomena in the 18th century.[52]

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[51] Wallace W. Atwood, Jr., "The International Geophysical Year: A Twentieth Century Achievement in International Cooperation," *Department of State Bulletin* 35 (Dec. 3, 1956), p. 880.

Organization of the Program

Programs of the IGY were selected primarily to assist in solving specific planetary problems of the earth, criteria for selection having been specified by the CSAGI as follows:

> (i) Problems requiring concurrent synoptic observations at many points involving cooperative observations by many nations.
>
> (ii) Problems of branches of geophysical sciences whose solutions will be aided by the availability of synoptic or other concentrated work during the IGY in other geophysical sciences.
>
> (iii) Observations of all major geophysical phenomena in relatively inaccessible regions of the earth that can be occupied during the IGY because of the extraordinary effort during that interval, in order to augment our basic knowledge of the earth and of the solar and other influences acting upon it.
>
> (iv) Epochal observations of slowly varying terrestrial phenomena, to establish basic information for subsequent comparison at later epochs.[53]

Where questions of priority arose, the first requirement (i) was recognized as controlling. This emphasis upon synoptic observations, the need for carrying out measurements throughout the entire globe, and the great expense necessitated in so doing, were all major elements in the readiness of the Congress to provide the needed funds, as discussed earlier.

Primary emphasis of the IGY, as summarized by the National Academy of Sciences, was

> . . . to observe geophysical phenomena and to secure data from all parts of the world; to conduct this effort on a coordinated basis by fields, and in space and time, so that results could be collated in a meaningful manner.[54]

Within this context, problems generally fell within these three broad areas:

> (a) The earth itself as a structure;
>
> (b) Atmospheric and oceanic circulation and heat and water budget of the earth; and
>
> (c) Upper atmospheric physics and solar-terrestrial relationships.[55]

TABLE 4. SCIENTIFIC AREAS REPRESENTED DURING THE IGY

Aurora and airglow[1]
Cosmic rays[1]
Geomagnetism[1]
Glaciology
Gravity
Ionospheric physics[1]
Longitudes and latitudes[1]
Meteorology[1]
Nuclear radiation[1]
Oceanography[1]
Seismology
Solar activity
Upper atmospheric studies utilizing rockets and satellite vehicles

[1] Disciplines of major interest.

Reference: Report on the U.S. Program for the International Geophysical Year (Washington: National Academy of Sciences-National Research Council, November 1966), p. vii.

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[52] *NAS IGY Program Report*, p. vii.
[53] *CSAGI, Bulletin d'Information*, No. 4 (London: IUGG Newsletter No. 9, 1955), pp. 54–55.
[54] *NAS IGY Program Report*, p. vii.
[55] *NAS IGY Program Report*, p. vii.

These broad areas were subdivided into 13 scientific areas, as shown in table 4. Of these, first priority was given to those requiring concurrent, coordinated observation, as indicated in the table. The remainder, including glaciology, gravity, and seismology, did not require synoptic observations, but were included because scientists would be available in areas where these fields, too, could be studied. Comprehensive summaries of activities carried out in each of these disciplines have been published by the National Academy of Sciences and will not be described in detail here.[56] However, a capsule rationale for inclusion of these particular disciplines is given below.[57]

Synoptic studies of the aurora were planned, particularly relative to magnetic storms. Also planned were the improvement of auroral charts, detailed spectrographic and photometric studies, and study of airglow phenomena. Of particular interest was the detailed characterization of the Antarctic aurora, of which little was known. By the use of artificial earth satellites, scientists hoped to learn more about the cause and formation of the aurora. Studies were planned to determine the solar and geophysical effects of cosmi rays, including their relation to the magnetic fields of the sun, the earth, and space, as well as their interaction with the atmosphere. Plans for geomagnetic studies included the morphology of magnetic storms and transient effects, relations with the ionosphere, and the equatorial electrojet. Particular interest was to be focused upon greater understanding of the earth's magnetic field as it extended into outer space.

Glaciology studies were not originally planned as part of the IGY, primarily because they did not meet the requirement for concurrent sunoptic observations. The importance of such studies was well recognized, however, because of their influence upon heat balance and chemical problems of meteorology. Glaciers affect the world's weather, although admittedly less than atmospheric disturbances and changes in the oceans. However, since IGY activities would necessarily result in the presence of many scientists in the Arctic and Antarctic regions, it seemed reasonable to take advantage of their presence to conduct glacier surveys to establish a data base which would permit determination of glacial changes by comparison with similar surveys in the future.

Plans for ionospheric studies included extensive recordings of layer heights, radio absorption and scatter effects, and galactic noises. Of special interest were plans for conducting ionospheric experiments northward from the South Polar plateau during the long, total-night season to shed light on the physical characteristics of the ionosphere during periods of prolonged absence of sunlight. Studies of latitude and longitude were planned primarily to improve time determinations and star catalogs, and to determine irregularities in the earth's rotation. Plans for meteorological studies included global atmospheric circulation, energy content and dynamics, ozone, cloud physics, and radio atmospherics and electricity. Plans for oceanographic studies were included because of the interrelationships among the oceans, the weather, and terrestrial dynamics, and also because of the enormous natural resources of the oceans. It was well known that the oceans exert a sizable impact upon the weather of the lower atmosphere, and it was hoped that investigation of the deep ocean basins would shed light on the structure and history of the earth.

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[56] *NAS IGY Program Report*, pp. 3–661.

[57] For more detail concerning the U.S. IGY program, see: Senate, *Hearings on H.R. 9936*, pp. 543–549; and U.S., Congress, House, Committee on Appropriations, *The Supplemental Appropriation Bill, 1959, Hearings*, 85th Cong., 2d sess., 2 July 1958, pp. 804–814. Much of the summary in the text is also based upon information from: Sullivan, *Assault*, p. 346; Sullivan, "The International Geophysical Year," *International Conciliation* (January 1959), p. 275; Roberts, "The IGY in Retrospect," pp. 266–268; Chapman, *Year of Discovery*, p. 12; and Chapman, "International Cooperation," p. 174.

Plans for seismological studies were included as part of the general effort to gain further understanding of the solid earth: its form, size, and rotation; its bodily tides; and its earthquakes, which provide the best means of studying the interior of the earth. Solar activity plans included observations of radiation, sunspots and flares, the corona, and general spectroscopy. It was known that the "electrical weather' was greatly influenced by changes in the sun, and it was hoped that' these studies, utilizing vastly improved instruments, would advance man's knowledge of these changes, particularly in the Antarctic. Finally, upper atmospheric studies were included because of their close relation to large-scale topography determinations of the earth. Such determinations depend partly on radio time signals between distant astronomical observatories. Intensive studies of the upper atmosphere enabled the time of passage of such signals to be estimated with high accuracy. Considerable interest existed in obtaining complete north-south profiles of air circulation and the electrified layers of air above the weather. Much interest also concerned explorations of outer space. It was anticipated that satellite vehicles would provide otherwise inaccessible information concerning the aurora, fluctuations in the earth's magnetic field, the influence of solar ultraviolet and other radiations, and cosmic ray phenomena, as well as providing scientists with their first views of the earth from outside its atmosphere.

Implementation of the Program

Various participating nations devised separate means for implementing their individual IGY programs, but all of these diverse programs were coordinated on an international level by the CSAGI and its advisory council, as shown schematically in figure 5. The U.S. technical program was directed by the IGY Committee of the National Academy of Sciences, in cooperation with many scientists from both public and private organizations and institutions. Technical panels, representing the various scientific disciplines, were established to plan the basic technical program for each discipline and assure its execution by appropriate groups of scientists.

The overall tasks of program and budget planning, of coordinating various activities among projects and related scientific fields, of assisting in the technical direction of the U.S. program, and of preparing technical and general articles on operations and results, were under the direction of the National Academy of Sciences IGY staff, working closely with the USNC.[58]

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[58] *NAS IGY Program Report*, p. viii.

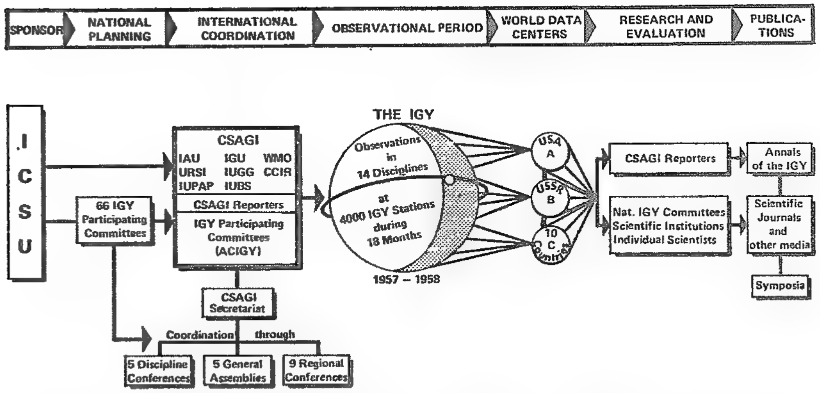

FIGURE 5. International Coordination of the IGY. From: Wallace W. Atwood, Jr., "The International Geophysical Year in Retrospect," *Department of State Bulletin* 40 (May 11, 1959), p. 687.

IGY REPORTERS

Coordination of various IGY programs was enhanced through the appointment of 14 reporters, each of whom was responsible for a particular scientific area.[59] The reporters were scientists chosen for their demonstrated ability and wide previous experience. They organized the discussion and planning of the central program, prepared working manuals, made plans for data collection and publication, and assisted in the analysis and interpretation of the data.

DATA CENTERS

It was evident at the outset of the IGY that free exchange of data, and protection of data from loss, would be essential ingredients of the undertaking. One unfortunate aspect of the SPY had been the loss of much data, both through delays in reporting and because of destruction of records during World War II. Therefore, most of the scientific observations made by IGY were collected at three World Data Centers. Two of the centers, one located in the United States [60] and the other in the Soviet Union, maintained complete duplicate records of all data collected. The third center consisted of a number of partial centers maintained by individual participating countries in one or more specific disciplines.[61] Duplication of records in this way assured their safekeeping from loss by fire or other catastrophe, and each center provided copies of data, in whole or in part, to any qualified applicant at cost.[62]

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[59] For a complete list of subject areas and individuals who served as reporters, see Wilson, *New Moons*, p. 334.

[60] World Data Center A, assigned to the United States, consisted of 11 subcenters: visual auroral observations (Cornell University); instrumental auroral observations (University of Alaska); airglow and ionospheric physics (National Bureau of Standards, Central Radio Propagation Laboratory): cosmic rays (University of Minnesota); geomagnetism, gravity, and seismology (U.S. Coast and Geodetic Survey); glaciology (American Geographical Society); latitudes and longitudes (U.S. Naval Observatory); meteorology (U.S. Weather Bureau, National Weather Records Center); oceanography (Agricultural and Mechanical College of Texas); solar activity (University of Colorado, High Altitude Observatory); and rockets and satellites (National Academy of Sciences). From U.S., Congress, Senate, Committee on Appropriations, *The Supplemental Appropriations Bill, 1959, Hearings on H.R. 13450*, 85th Cong., 2d sess., July 22, 1958, p. 360. Subsequently referred to as: Senate, *Hearings on H.R. 13450*.

[61] Senate, *Hearings on H.R. 13450*, p. 360. The locations were: Japan, Australia, and Western Europe.

WORLD DAYS AND ALERTS

A major objective of the IGY was to obtain simultaneous observations of phenomena by observers distributed throughout the world. To achieve this capability, a communications headquarters was established at Ft. Belvoir, Va., to notify participants when interesting phenomena developed, like sudden flareups on the surface of the sun or a fast-developing solar storm. At such times an alert would be called which might be followed by a special world interval during which more intensive observations of phenomena would be undertaken. In addition, certain world days were selected in advance for intensive worldwide observation of particular phenomena, as well as world meteorological intervals for the making of special weather observations. These events are indicated in figure 6.

PUBLICATION OF RESULTS

Essential to most scientific undertakings is the publication of results. Because the results of the 2 polar years had been published primarily by the participating countries as they saw fit, few copies were printed; many important scientific libraries still lack copies. To avoid such a gap in programing, arrangements were made to publish IGY results in an international journal created for that purpose: the *Annals of the IGY*. In this journal were published not only the results of IGY observations, but a history of the IGY, and a brief account of the 2 polar years.[63]

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[62] For additional information on the World Data Centers, see: Chapman, *Year of Discovery*, p. 107; and Chapman, "International Cooperation," p. 175.

[63] Chapman, *Year of Discovery*, p. 107.

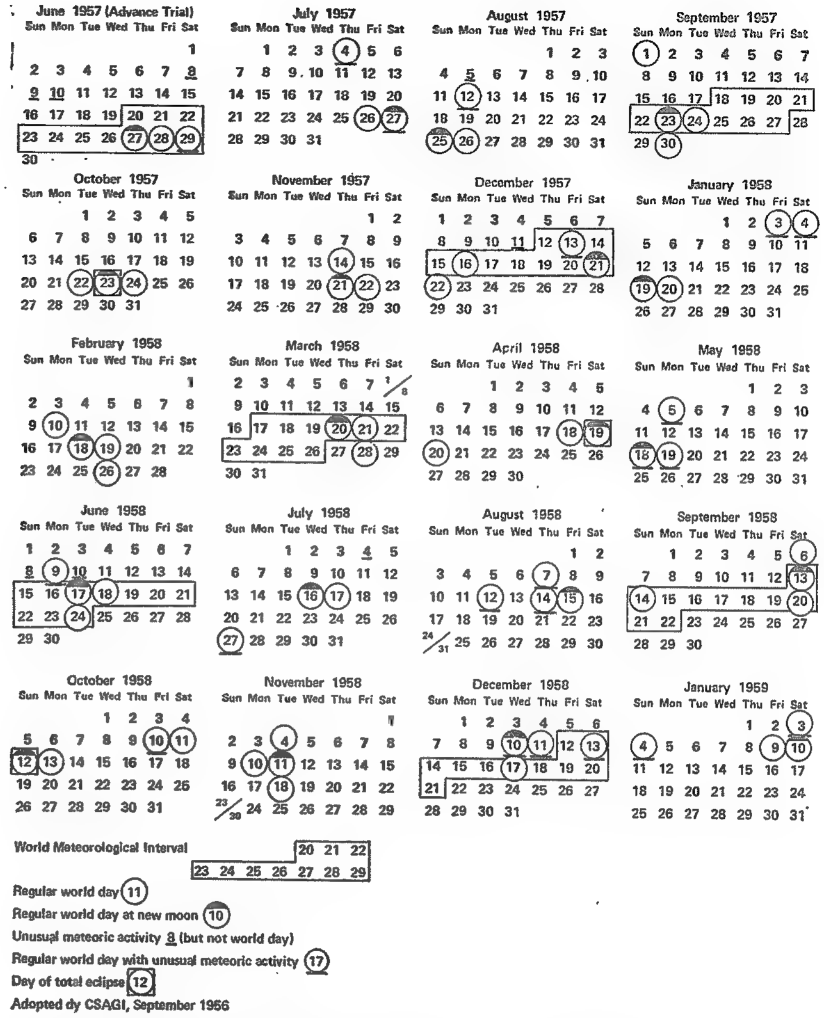

FIGURE 6. The IGY Calendar of Special Events. From: Sidney Chapman, "*IGY: Year of Discovery. The Story of the International Geophysical Year* (Ann Arbor: University of Michigan Press, 1959), p. 103.

"GEMÜTLICHKEIT"

Much has been written about the spirit of cooperative good will that existed among scientists during the IGY and which continued in large measure thereafter. Dr. Joseph Kaplan, Chairman of the U.S. National IGY Committee, observed that both the national and international planning for the IGY were marked by a spirit of "objectivity and harmony." [64] Wallace W. Atwood, Jr., then Director of the Office of

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[64] Testimony in *NSF–NAS Hearings: IGY Report*, p. 6.

International Relations of the National Academy of Sciences, remarked that "scientists from countries whose political leaders were snarling at each other worked on in amity . . . ." [65] Walter Sullivan, science writer for the New York Times assigned to cover the IGY full time, remarked that the program was ". . . carried forward by a seemingly irresistible tide of scientific enthusiasm." [66] Sidney Chapman commented upon the "co-operative and harmonious spirit" among the scientists of the 67 nations associated with the IGY, pointing out that "Their common interest in its subject and purposes made it possible for them to work together despite differences of race, creed, or political organization." [67]

J. Tuzo Wilson, who served as president of the IUGG during the IGY, attributed this cooperation and harmony to the fact that "The senior scientists trusted one another and expected, in turn, to be trusted. Generally speaking, this faith was justified and generated confidence." [68] However, Wilson recognized that all political influences in so broad an undertaking could not completely be avoided, and that the scientists involved were not unrealistic in their expectations in that ". . . the participants were alive to human frailty and to the reality of political influences, so they did not expect perfection." [69] Although, according to Atwood, "At no time did the scientists allow political differences to block their course," [70] nonetheless, such differences did on occasion arise and had to be dealt with.

Political Constraints on the Program

Political constraints upon the IGY were minimized by adherence to a fundamental principle of the ICSU and its affiliated bodies: that scientists from any country or territory were welcomed as participants, and that such participation carried no implications for diplomatic recognition of the government of the country or territory concerned. As pointed out by Atwood, "This principle made possible the virtually universal enrollment of national scientific communities in the IGY." [71] However, the principle could not at times surmount the *de facto* recognition which the existence of national committees implied, particularly when two opposing groups or committees claimed the same nationality.

THE TWO CHINAS

Political difficulties concerning the two Chinas—the People's Republic of China (Red China) and the Republic of China (Nationalist China)—were perhaps the most marked of all political influences that affected the IGY. According to Chapman, these difficulties left the members of the CSAGI with ". . . some of their most painful IGY memories." [72] Given the attitudes of the protagonists, the problem was inherently insoluble.

The People's Republic of China formed an IGY Committee late in 1955 through the Peking Academia Sinica, which had built a worldwide reputation for scientific scholarship. The Peking Committee

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[65] Atwood, "The IGY in Retrospect," p. 682.
[66] Sullivan, "The IGY," p. 299.
[67] Chapman, *Year of Discovery*, p. 107.
[68] Wilson, *New Moons*, p. 326
[69] Wilson, *New Moons*, p. 326.
[70] Atwood, "The IGY in Retrospect," p. 688.
[72] Atwood, "The IGY in Retrospect," p. 684.
[72] Chapman, "International Cooperation," p. 178.

announced that it would participate in the IGY upon the condition that the Chinese Nationalists would not. Peking participation was accepted by the CSAGI despite this condition, which was essentially ignored as irrelevant since the Nationalist Chinese had not responded to an invitation sent 3 years earlier. In 1956, however, the Nationalist Chinese indicated a desire to participate, demanding that the Peking group be excluded. This demand, which was rejected by the CSAGI, subsequently was withdrawn in 1957 by the Nationalist Chinese, who then officially joined the IGY. The Peking group thereupon withdrew. Sullivan has called this action ". . . the only case in which the IGY was significantly affected by political considerations." [73]

SOVIET MISSILES

Political considerations also influenced the extent to which the Soviets released data concerning their Sputnik satellites. It had been agreed among IGY participants that, before the launching of any satellites, certain data would be released, including time of launch; weight, shape, and dimensions of objects placed in orbit; and information concerning transmission of data and details of orbit. It soon became apparent that the U.S.S.R. was not prepared to release all the agreed-upon information, primarily because military rockets had been used to launch the satellites and it was feared that such information would disclose military secrets, especially with regard to the location of launch sites. Much discussion during the latter part of the IGY concerned exactly what satellite-related information the Soviets would release. However, the American and Soviet representatives were never able to reach complete agreement on this issue. American representatives, to be sure, were at a decided advantage in that information on Vanguard firings, largely utilizing nonmilitary hardware, was quite open and unrestricted by comparison.

ARCTIC FLIGHTS

One aspect of Arctic studies centered around the fact that little information was available concerning drifting ice in the Arctic Ocean, sometimes clogging Alaskan waters, sometimes Siberian. Hence, American scientists suggested to Soviet scientists that a cooperative program be established to enable aerial photographic mapping of the Arctic ice packs and their patterns of drift. Soviet scientists accepted the suggestion, proposing that flights be made between Murmansk and Fairbanks, which would permit mapping of the entire Arctic ocean. This suggestion was vetoed in Washington, however, apparently because two important Air Force bases had been built near Fairbanks. Instead, Washington proposed that flights terminate at Nome, a much less satisfactory location than was Fairbanks. Meanwhile, the Hungarian and Suez crises erupted in 1956, and the Soviet reply to the American suggestion of Nome was that the Soviet Air Force would map the Siberian side by itself. Thus, a mixture of political and military considerations prevented the implementation of the scientific program as originally conceived.

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[73] Sullivan, "The IGY," p. 294.

RADIOACTIVE FALLOUT

Much thought was given by meteorological scientists during the IGY to determination of air mass movements by the use of radioactive fallout techniques. In particular, plans were made to determine the extent of nuclear radiation in the atmosphere, the amount of fallout reaching the ground, and the quantity of dust already accumulated. Although indications were that Soviet IGY leaders backed the program, Soviet scientists did not participate. Sullivan has speculated that rejection of Soviet participation was ". . . a political decision in Moscow not to take part in any activity which implied that fallout had some usefulness." [74] Nonetheless, a limited fallout study was conducted by other IGY participants.

ANTARCTIC BASES

A significant proportion of IGY activities was carried out in the Antarctic, where a number of participating nations had made territorial claims, some of which overlapped. It was therefore inevitable that political considerations could not be completely excluded from the Antarctic program. In particular, it was clear that Australian representatives were disturbed over the establishment of Soviet bases that close to Australia, and the extent to which such bases appeared of a permanent nature. Through informal agreement and mutual understanding, however, these various claims were not enforced in any way, thus permitting the Antarctic program to be pursued largely unaffected by such claims.

MAPPING

Soviet delegates to the IGY proposed that all expeditions to the Antarctic cooperate in preparing a detailed map of the continent primarily through aerial photography. This proposal was rejected on the grounds that mapping did not meet the basic requirements for IGY programs. American participants also objected to the program on the grounds that mapping represented a quasi-political activity which should not be included in what otherwise were purely scientific activities. The American view was inadvertently reinforced when the U.S. Navy, in its Operation Deepfreeze plan, used the phrase "United States rights in the area," [75] a phrase to which the American scientists strongly objected. Although the Soviets eventually proceeded to map half the continent, the American contingent did not participate in these activities. Subsequent technological developments in reconnaissance by artificial satellites have rendered the disagreement irrelevant.

THE "STOLEN" SATELLITE ROCKET

Politics also intruded into the IGY with regard to the recovery of the rocket which launched Sputnik I. By coincidence, a large meteor fell over Alaska almost precisely at the time predicted for the final pass of the Soviet rocket over that area. Subsequently, local U.S. Army headquarters erroneously announced that the rocket had fallen into an Army reservation in the vicinity of Fairbanks. Soviet Premier Khrushchev commented later, "We know [the rocket] fell on the United States, but they do not want to give it back to us." [76] Correspondence regarding the rocket and its recovery then ensued between the Soviet and American IGY committees, until the American delegates were able to demonstrate conclusively that the rocket must have fallen in Siberia rather than in Alaska.

CENSORSHIP

A basic principle of the ICSU, and therefore of the IGY, was that all scientific information would be reported as soon as possible and thereafter quickly disseminated to all interested parties. However, some newspaper and radio reports covering a CSAGI conference in Moscow, held from July 29 to August 9, 1958, were held up by Soviet censors. Chiefly, the censored material concerned Japanese information regarding radioactive rain samples which demonstrated that radioactivity in Japanese rainwater resulted primarily from Soviet nuclear weapons tests. Protests over this censorship of reporting IGY results successfully prevented further censorship, and news stories that had been held up were released.

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[74] Sullivan, "The IGY," p. 282.

[75] Operation Deepfreeze, Operation Plan No. 1-55, Commander, U.S. Naval Support Force, Antarctica, p. 2. For details, see: Sullivan, *Assault*, p. 402.

[76] *New York Times*, Dec. 7, 1957, p. 1.

IV. The Scientific Results

Tremendous masses of data were obtained during the IGY. For example, approximately 17 tons of records were generated by American Antarctic stations alone. This dramatic outpouring of information posed more questions than were answered. Berkner likened the situation to that of coming from outer space and finding a new planet.[77]

Summary of Scientific Findings of the IGY

The assimilation of this wealth of new information required considerable time, and the process is still continuing. However, comprehensive summaries of the major scientific results of the IGY are available,[78] as well as numerous more popularized summaries.[79] Hence, only a brief synopsis of the major findings will be given here.[80]

AURORA AND AIRGLOW

It was found that the aurorae are continuous along a "magnetic dip line" on the dark side of the earth, and that movements within them pass from west to east. Also discovered was the fact that airglow results from light emitted upon the decay of chemical compounds formed in the outer fringes of the atmosphere by incident solar energy, and that auroral displays typically result from solar activity. Following a particularly outstanding solar flare during the IGY, activity was observed at altitudes as high as 800 kilometers, and the effects were visible as far south as Cuba. Worldwide disruptions in communications by radio, land telegraph lines, and ocean cables were observed. For example, magnetic activity in the upper atmosphere induced potentials in transatlantic cables of up to 2,650 volts.

COSMIC RAYS

Cosmic rays, believed to represent possibly half of all the energy in the universe, were found to be influenced by solar activity, with diminished cosmic ray intensity being noted during periods of high sunspot activity. However, fundamental questions concerning the origin and nature of cosmic rays remained unanswered. Sullivan commented that cosmic ray physics ". . . emerged from the IGY as . . . the broadest-ranging of all man's intellectual endeavors," dealing not only with the immense concepts of galaxies and intergalactic space, but with the opposite spectrum of atomic and nuclear particles and forces as well.[81]

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[77] Roberts, "The IGY in Retrospect," p. 269.

[78] See, for example, the *NAS IGY Program Report.*

[79] Included are: Chapman, *Year of Discovery;* Sullivan, *Assault;* and Wilson, *New Moons.*

[80] Summarized primarily, but not exclusively, from: Roberts, "The IGY in Retrospect," pp. 269–284; Atwood, "The IGY in Retrospect," pp. 686–688; and Odishaw in *NSF-NAS Hearings; IGY Report*, pp. 23–48.

[81] Sullivan, *Assault*, p. 211.

GEOMAGNETISM

IGY magnetic observatories and recording stations provided working material for extensive investigations into many aspects of natural electric and magnetic phenomena and their relation to solar events. Existence of an equatorial electrojet—a powerful, concentrated stream of current close to the magnetic equator—was confirmed, chiefly on the sunlit side of the earth. Currents in the earth's crust, induced from ionospheric currents, were found in unexpectedly great intensity and wide distribution. Additional light was shed on the old and unresolved question of whether any real correlation of meteorological and geomagnetic effects exists. Many unknown magnetic anomalies were discovered in the ocean depths.

GLACIOLOGY

IGY investigations showed that ice depths may extend to more than 14,000 feet, giving rise to estimates that the ice content of the earth is about 4.5 million cubic miles, or 40-percent greater than previously thought. Approximately 90 percent of this ice is in Antarctica. New information dramatically advanced the theoretical analysis of glaciers, especially theories concerning the deformation and flow of ice, and the heat flow in ice sheets.

GRAVITY

New gravimeters, faster and more portable than the classic pendulum apparatus, were used during the IGY to carry out widespread detailed surveys of the earth's gravitational field. Results showed that the earth's mass distribution is highly irregular, with regard not only to mountains and ocean depths, but also to hidden ore bodies and structural irregularities of the earth's rocks. Antarctic profiles were obtained, as well as information concerning the earth's tides and the rise and fall of the earth's crust (approximately 6 inches in amplitude at Washington, D.C.). Much was learned concerning knowledge of the elastic constants of the earth and its crust, and of world mass distribution.

IONOSPHERIC PHYSICS

Research showed that although ionospheric electric currents exist everywhere in some form, they are especially intense and complex in the auroral zones. A particularly strong electric current was found close to the earth's magnetic equator. Much information was obtained concerning neutral and ionized ionospheric gases and their effect upon radio communications, particularly as a function of radio frequency.

LONGITUDES AND LATITUDES

Improved measurements were made with the help of special moon-position cameras located at 20 astronomical observatories distributed around the world. These cameras were capable of taking simultaneous exposures of the moon and surrounding stars while holding the moon's image fixed relative to the stars. By taking several observations on a single night at a given station, it was possible to fix the position of that station accurately relative to the center of the earth, without dependence upon a plumbline.

METEOROLOGY

Possibly the most important IGY contribution to meteorology was the study of Antarctic weather. Old theories of air circulation were disproved, and fundamental contrasts with northern polar weather were made possible. In particular, it was found that the Antarctic continent did not, as previously thought, impede the free flow of tropospheric winds across it, distributing heat and moisture and greatly slowing temperature drops during the polar night. Rather, stratospheric air masses were found to be contained by a strong jet stream which encircles the continent and causes continuously dropping temperatures in the winter. Much of what was learned during these IGY studies should assist in developing better weather prediction capabilities, as well as contributing to long-range efforts to exercise some degree of control over the earth's weather.

NUCLEAR RADIATION

IGY experiments confirmed the fact that atomic bursts in ionospheric regions can produce artificial radiation and other widespread effects similar to those produced by nature. By exploding small nuclear devices between the Van Allen radiation belts, the scientists injected a known quantity of electrons of known energies into the earth's magnetic field at known times and places, thus producing artificial auroral luminescence. These experiments represented the first time in history that worldwide synoptical measurements were made on a completely controlled geophysical phenomenon.

OCEANOGRAPHY

Studies of ocean currents demonstrated that the ocean depths are very much in motion. The discovery that movements were much greater than those necessary to compensate for windblown currents on the surface led to the conclusion that thermal forces are primarily responsible for the massive circulation of ocean water. Three major countercurrents—one in the Atlantic flowing deep beneath the Gulf Stream, and two in the Pacific—were located, clocked, and measured. Studies of the deep ocean trenches of the Pacific showed that life, including fish, crustaceans, and fauna, exists even under conditions almost 40,000 feet below the surface. Also, it was shown that, contrary to previous belief, the water of deep ocean trenches is not stagnant, and hence it was demonstrated that such trenches are unsuitable for dumping of radioactive wastes.

SEISMOLOGY

The IGY afforded unique opportunities to place seismographic recorders in remote parts of the world, particularly in the polar regions. Antarctic observations were especially useful in obtaining valuable readings on a broad range of far-southern quakes covering a vast area, and for helping to determine propagation velocities through ocean crustal formations. Reflected waves from small surface explosions were used to determine subsurface structure, disclosing the ice depths in Antarctica and Greenland, and providing information about the continental structure of Antarctica. Explorations in South America showed the crust of the Andean massif to be unexpectedly thin. Ground waves of ultralong period were subjected to intensive study, demonstrating the value of such waves in detecting distant earthquakes and underground explosions.

SOLAR ACTIVITY

IGY studies resulted in unprecedented observations of solar activity, including an almost complete record of hydrogen gas flares. Observations were enhanced by occurrence of the greatest number of sunspots since 1612, when such phenomena were first observed by Galileo. Solar clouds were shown to be the source of ultraviolet light, solar flares the source of gamma radiation, and the corona the source of X-rays.[82] Magnetic fields of varying intensities were found to accompany sunspots and flares, with residual magnetic fields extending outward possibly beyond the solar system. Possibilities were raised that much thermal energy might be transferred to the earth's atmosphere by way of direct contact with the thin but hot gases of the sun's corona.

UPPER ATMOSPHERE

IGY research established that there is no definite end to the earth's atmosphere. As far distant as 10 earth diameters a substantial hydrogen atmosphere was found to exist, fading into the atmosphere of outer space itself, dominated by the effects of untold meteors, X-rays, ultraviolet light, protons, electrons, cosmic rays, and electric and magnetic fields. Thus, the upper atmosphere was found to be a place of considerable activity, affecting many phenomena on the earth itself. Of tremendous interest was the discovery of the two Van Allen radiation belts, existing as annular shrouds about the earth, shaped by terrestrial magnetic fields. These belts of intense radiation were seen as important factors in determining and perhaps limiting man's future exploration of space.

Appraisal of Findings

If one particular field of activity were to be singled out as the most outstanding scientific achievement of the IGY, it would undoubtedly be the launching of artificial earth satellites. Although the IGY was primarily an exercise in pure science, one of its primary objectives was to exploit contemporary technology in the pursuit of scientific objectives. The launching of the IGY artificial earth satellites represented a remarkable technological achievement that, despite advance warning, it nonetheless created astonishment and a sense of wonder throughout the world. Thus, these scientific space probes clearly initiated the space age, opening a new era of exploration and discovery which has progressed much more rapidly than could possibly have been foreseen during the IGY. Sullivan has likened the scientific importance of orbiting the first artificial satellites to the release of atomic power,[83] and has commented as follows:

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[82] X-rays are emitted when a beam of high-velocity electrons impinges upon a suitable metallic target within an evacuated, or partially evacuated, glass tube. Powerful natural emitters of X-rays outside the solar system are believed to include radio sources, and novae and supernovae. Gamma rays, similar in many respects to X-rays but generally of higher frequency and greater penetrating power, are emitted upon the decay of radioactive substances.

> By now, references to the Space Age have become hackneyed, yet upon reflection it seems possible that, a thousand years hence, the year 1957 will be to the schoolchildren of the world what 1492 is to young Americans today. In 1492 the Old World opened the door to the New; in 1957 man opened the door to the solar system, and perhaps beyond.[84]

Furthermore, it was the IGY space satellite program which led to the aforementioned discovery of the Van Allen radiation belts, characterized by Roberts as "one of the great physical science discoveries of all time," the implications of which "are yet unimaginable, but they are certainly tremendous—quite possibly comparable with those attending the discovery of radio waves." [85]

If the launching of artificial earth satellites was the most outstanding IGY accomplishment, then the exploration of the Antarctic was undoubtedly the next greatest achievement. Before the IGY, most of man's knowledge of his native planet had been based on data derived from observations made on the six continents he inhabited; Antarctica remained the unknown continent.[86] On a global scale, information regarding atmospheric circulation, ionospheric conditions, and geological history of the earth necessarily remained incomplete. IGY activities initiated in the Antarctic and continued thereafter

> . . . resulted in numerous significant discoveries which contributed to better knowledge and a clearer picture of the physical processes of [the earth]. Geologic, paleontologic, and paleomagnetic discoveries . . . were largely responsible for the revival of the Continental Drift theory and the emergence of a new and more accurate picture of Earth's geology, this time with the seventh continent included.[87]

The IGY was, of course, much more than the launching of earth satellites and exploration of the Antarctic, dramatic as those accomplishments were. It was, according to Kaplan, "primarily a program of basic research, a seeking after first causes." [88] Atwood has described it as "a good program, carefully planned, and magnificently executed," which led to "new scientific knowledge of untold wealth." [89] In particular, important new discoveries were made regarding man's environment, the earth itself, the oceans, and the atmosphere. Thus, as stated by Roberts,

> The borders of our knowledge of man's environment were pushed back in several important respects, with an already vast and growing store of new knowledge which will sharply influence the course of human development.[90]

The mere production of data is in itself no guarantee of scientific advancement. The IGY did much more than generate data: it produced new scientific understanding and knowledge. It permanently increased both the amount and quality of geophysical and solar observations, served to catalyze much research that might never have been initiated otherwise, stimulated thought and imagination in opening up unparalleled new horizons, and transformed earth science into planetary science. As summarized by Wilson, it "vastly enlarged the scope of man's activities and gave him a new vision of his place in the universe." [91]

Continuation of IGY Programs

One of the major scientific outcomes of the IGY was the establishment of new means—and new international organizations—to continue many of the scientific undertakings initiated or expanded during the IGY. Without the IGY, these programs might have been delayed for many years or possibly might never have been initiated at all. Major credit for the continuation of many programs was due the ICSU, which, through CSAGI, had begun to consider as early as June 1957 proposals for the formation of new groups through which the central IGY organization could be perpetuated. The first such group to be formed was the Special Committee on Antarctic Research (SCAR), established in March 1957. There soon followed creation of the Special Committee on Oceanic Research (SCOR), which held its first meeting at Woods Hole, Mass., during the period August 28–30, 1957.

A broad program for establishing special committees for continuing IGY activities in various fields, as exemplified by SCAR and SCOR, was given general endorsement by the CSAGI at its fifth assembly meeting in Moscow during the period July 30 to August 9, 1958, at which time the name International Geophysical Cooperation—1959 (IGC–1959) was coined to describe the program.[92] In a sense, this proposal represented a compromise between the Soviet and American positions on formal continuation of the IGY. The Soviet leaders, it appeared, had a very urgent and demanding need for both the IGY name and the IGY organization to help maintain their position at home.[93]

A direct continuation, however, posed a delicate problem for the American scientists, who had repeatedly emphasized to the Congress that the IGY was to be a specific, time-limited undertaking. Early in 1954, while seeking the initial appropriation for the IGY, Dr. Waterman had pointed out that the scientific community regarded the activity as "a one-shot program." [94] Early the following year, in seeking additional appropriations, Dr. Berkner, speaking on behalf of the USNC, agreed that a cutoff date of July 1960 would be satisfactory for the U.S. program.[95] This agreement was somewhat qualified later in the year when Berkner, looking forward to the post-IGY period, raised the possibility of further development of IGY activities.[96] Although this possibility fell upon receptive congressional ears, the American position had become solidified to the extent that support for the Soviet direct continuation proposal was impractical. Thus, as Waterman explained:

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[83] Walter Sullivan, "The IGY—Scientific Alliance in a Divided World," *Bulletin of the Atomic Scientists* 14 (May 1958), p. 72.

[84] Sullivan, *Assault*, pp. 2–3.

[85] Roberts, "The IGY in Retrospect," p. 264.

[86] George Doumani, "Science Policy for Antarctica," *Bulletin of the Atomic Scientists* 24 (April 1968), p. 39.

[87] Doumani, "Science Policy for Antarctica," pp. 39–40.

[88] Joseph Kaplan, "What We've Learned from the IGY," *The Rotarian* 108 (March 1959), p. 10.

[89] Atwood, "The IGY in Retrospect," p. 689.

[90] Roberts, "The IGY in Retrospect," p. 263.

[91] Wilson, *New Moons*. p. 324.

[92] *NAS IGY Program Report*, p. vii.

[93] Sullivan, *Assault*, p. 409.

[94] House, *The Supplemental Appropriation Bill, 1955*, p. 936.

[95] House, *Independent Offices Appropriations for 1956*, p. 320.

[96] Senate, *Hearings on H.R. 5240*, p. 447.

> The Russians have proposed an extension recently, but our delegation feels this would be a mistake. It may be that certain special fields of global interest might be continued in some cooperative way, but this would not be desirable, in our opinion, for the complete IGY program.[97]

Acceptance of the IGC–1959 as the "some cooperative way," leaving the extent of participation entirely up to each participant, helped resolve the conflicting American and Soviet positions.

The proposal for the IGC–59 was endorsed by the ICSU during its meeting in Washington, October 2–6, 1958, at which time a successor body was created, the Special Committee for Inter-Union Cooperation in Geophysics (SCG) of the ICSU. The last meeting of the CSAGI and the first meeting of the SCG were held concurrently in May 1959, both committees having essentially the same representation. At this joint meeting it was proposed that a committee somewhat different in composition from the SCG be formed, a Comita Internationale de Geophysique (CIG) which would be composed of a larger membership, including the IGY reporters. This proposal was approved by the ICSU Executive Board in October 1959 and the first meeting of the CIG took place in November 1959. Thus, the CIG assumed essentially the same responsibilities for the IGC–1959 as the CSAGI had assumed for the IGY,[98] including publication of such IGY publications as the *Annals* and oversight and support of the work of the World Data Centers.[99]

Other organizations set up to continue various IGY programs included the Inter-Union Committee on Contamination by Extra-Terrestial Exploration (CETX), the Committee on Space Research (COSPAR), and the International World Days Service (IWDS).[100] Formation of these various organizations assured that work accomplished during the IGY was suitably reported and published, and provided for its continuation thereafter. The existence of these international organizations and programs must be considered one of the most important legacies of the IGY.[101]

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[97] Senate, *Hearings on H.R. 13450*, p. 364.

[98] *NSF-NAS Hearings: IGY Report*, p. 21. Testimony of Hugh Odishaw.

[99] *NAS IGY Program Report*, p. x.

[100] *NSF-NAS Hearings: IGY Report*, p. 21.

[101] For a comprehensive analysis of the organizational structure of the international scientific community and the role of COSPAR in particular, see: *International Cooperation and Organization for Outer Space*, pp. 353–426 and Richard W. Porter, "International Scientific Community: International Council of Scientific Unions and COSPAR" in: U.S., Congress, Senate, Committee on Aeronautical and Space Sciences, *International Cooperation in Outer Space: A Symposium*, 92d Cong., 1st sess., Dec. 9, 1971, pp. 527–557.

V. The Political Impacts

Much emphasis has already been placed upon the fact that the IGY was not an international undertaking in the literal sense of the term, but rather an internationally coordinated collection of otherwise independent national activities. These national activities, once approved and funded by their respective governments, were in turn almost exclusively under the control of individual scientists and thus were almost entirely apolitical. Berkner has emphasized the fact that the IGY programs were "operated *by scientists* [italics his], with the consent, cooperation, and aid, but not the direction, of governments."[102] The individualized nature of the activities has been underscored by Odishaw, who called the IGY "a gathering together of private human beings, each of whom had a vital personal interest in a particular subject, each of whom felt that this subject needed . . . a concerted attack."[103]

Despite this basic scientific individualism of the IGY, its ultimate impact reached considerably beyond individual scientists and the scientific community itself and was felt within the political community as well. Chapman, for example, commented that "it cannot be doubted that the IGY . . . had significant political results."[104] An examination of those political results is the primary purpose of this study. In carrying out this examination, it should be noted that the IGY represented a major technological achievement as well as a scientific achievement. Indeed, the eventual political impacts of the program perhaps owe more to IGY technology than to its science. In discussing the results of these impacts, it is well to keep in mind the fact that the specific technology employed in the artificial earth satellite program of the IGY required agreements among nations which subsequently made further agreements in related areas much easier to accomplish (see section VI). Thus, although primary emphasis in the preceding section has been given to the scientific results of the IGY, there is no intent in this study to minimize the importance of the technology employed in the pursuit of those results, especially insofar as the employment of that technology impacted upon subsequent political affairs.

In this section, the political effects of the IGY are examined first as they affected the United States, in both general and specific ways, and then as they affected the international political scene.

General Impacts on the United States

Political impacts of the IGY were felt within the United States on two levels, one general and one more specific. First, considerable impact was evident in general in what is frequently termed the "politics of science," which roughly may be considered a matter of "who spends how much money for what." It was inevitable that an undertaking of the magnitude of the IGY should benefit the earth sciences and shift attention toward projects supporting the four major goals discussed earlier in section III. To the extent that scientific manpower, technical resources, and available funds were allocated in support of IGY-oriented programs, the earth sciences clearly received high priority. A reflection of this emphasis is contained in the highly international philosophy that appears to have prevailed during the IGY period. Certainly the earth sciences benefited enormously, never before having enjoyed especially great largess as compared with more spectacular fields like high-energy physics or atomic energy. As Kaplan remarked,

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[102] Berkner, "Geography and Space," p. 313.

[103] From testimony in *NSF-NAS Hearings: IGY Report*, p. 20.

[104] Chapman, "International Cooperation," p. 174.

> The impact of the International Geophysical Year in the geophysical sciences has been remarkable. In my opinion, the International Geophysical Year has ushered in a new era in geophysics.[105]

Specific Impacts on the United States

On a more specific level were the large number of national impacts which occurred primarily as a result of the Soviet IGY artificial satellite program. The launching of artificial satellites was an important and integral part of the total IGY effort.[106] Although only two of the 67 participating nations—the United States and the U.S.S.R.—took part in these activities, they represented the world's two most powerful countries, and the proportions of their respective IGY outlays which went into the satellite effort were substantial.[107]

The possibility of launching artificial earth satellites had been discussed long before the IGY, and Van Allen had outlined the scientific usefulness of satellites as early as 1948.[108] In November 1953, the president of the Soviet Academy of Sciences told the World Peace Council in Vienna that "science has reached a state when it is feasible . . . to create an artificial satellite of the Earth." [109] In view of the optimism regarding the technology available for satellite launching and the ability to make measurements encompassing the globe through their use, it is not surprising that especially serious attention was given the use of satellites as part of the IGY.

At the Rome meeting of the CSAGI in 1954, a formal proposal was made that those nations able to do so should include artificial satellites within their IGY programs. In particular, it was felt by the CSAGI that use of such satellites should provide information regarding the aurora, the earth's magnetic field, the solar ultraviolet, X-ray and particle radiation, and cosmic ray phenomena that could not be acquired in any other way. As stated by Roberts, "A direct result of the agreement reached at Rome [was] that the United States and the Soviet Union embarked at this time on what was to become perhaps man's most adventurous scientific enterprise . . . destined to produce results far beyond the initial expectations of CSAGI." [110]

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[105] Testimony in *NSF-NAS Hearings: IGY Report*, p. 8.

[106] See for example: U.S., Congress, Senate, Committee on Aeronautical and Space Sciences, *Soviet Space Programs: Organization, Plans, Goals, and International Implications*, 87th Cong., 2d sess., May 31, 1962, p. 123. This staff study calls the launching of Sputnik I the IGY's "most dramatic event" (p. 173).

[107] As mentioned earlier in chap. 2, almost half of the $43 million appropriated by Congress for the IGY was used for earth satellite activities.

[108] Sullivan, "The IGY," p. 275. Some discussion took place in military department reports possibly as early as 1946.

[109] See F. J. Krieger, *Behind the Sputniks, A Survey of Soviet Space Science* (New York: Public Affairs Press, 1958), p. 3.

[110] Roberts, "The IGY in Retrospect," p. 268.

In retrospect, the way in which the Soviet and American responses to the CSAGI proposal developed can be held responsible to a large degree for the subsequent American, and world, reaction to Sputnik I. On April 16, 1955, only 6 months after passage of the CSAGI proposal, the Soviets announced creation of a Commission on Interplanetary Communication which, as one of its functions, was to organize work on the construction of artificial earth satellites.[111]

No mention was made of the IGY, however, and the report went largely ignored by the rest of the world.[112] Three months later, on July 29, 1955, President Eisenhower announced that artificial satellites would be launched as an integral part of the U.S. IGY program.[113] Unlike the earlier Soviet announcement, the Eisenhower announcement received widespread attention. Of particular interest was the U.S. plan to develop a nonmilitary rocket, the Vanguard, specifically for IGY purposes, rather than make use of existing military rockets. This decision was made by American scientists who hoped to develop not only their own launching rockets, but also the necessary tracking facilities, computers, and related support systems in order to ". . . remain independent of military security and military requirements and to develop a satellite designed solely for the gathering of scientific information." [114] Only a few days after the Eisenhower announcement of American plans, the Soviets announced that they, too, would launch IGY satellites, but no specifics were given at that time. Thus, the stage was set for the beginning of the "space race" between the two powers.

Following these initial announcements of IGY satellite activity, a number of further clarifying announcements were made from time to time by both participants. The gist of these remarks was that the American satellites would be relatively small, light spheres, about 20 inches in diameter, weighing about 20 pounds.[115] The original plan called for 12 rocket propulsion vehicles, thus theoretically making possible the launching of 12 instrumented research satellites.[116] Subsequently, the size of the satellites was revised somewhat higher, from 20 to 30 inches, inclusive, but the satellites continued to be popularly referred to as basketballs.[117] The U.S. effort was described by Dr. Homer E. Newell, Jr., who substituted for Berkner as CSAGI reporter for rockets and satellites, as being

> . . . simply an extension of the conventional rocket program, which in turn has been thought of as an integral part and natural extension of the overall IGY effort. [118]

Comment concerning the Soviet effort, on the other hand, indicated that Soviet satellites might be considerably heavier than the American ones,[119] and remarks of Soviet Academician Sedov indicated that Soviet military rockets might be used for the launchings:

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[111] Krieger, *Behind the Sputniks*, p. 330. The formation of the Commission, headed by L. I. Sedov, was announced in the newspaper *Vechernyaya Moskva*.

[112] Sullivan, "The IGY," p. 301.

[113] U.S., Congress, Senate, Committee on Aeronautical and Space Sciences, *Soviet Space Programs, 1966–70*, 92d Cong., 1st sess., Dec. 9, 1971, p. 160.

[114] Wilson, *New Moons*, p. 66.

[115] House, *Second Supplemental Appropriation Bill, 1956*, pp. 451, 461.

[116] House, *Second Supplemental Appropriation Bill, 1956*, p. 452.

[117] U.S., Congress, Senate, Committee on Appropriations, *Second Supplemental Appropriation Bill, 1956, Hearings on H.R. 10004*, 84th Cong., 2d sess., Mar. 20, 1956, p. 222. As the U.S. plan actually developed, the first Vanguard satellite was a 6-inch test sphere weighing 3.5 pounds, containing only a radio transmitter. Vanguard II weighed 20.7 pounds, and Vanguard III 100 pounds. These were the only Vanguard satellites launched: eight other attempts to orbit Vanguard satellites failed.

[118] Speech of Sept. 9, 1955, reproduced in the *CSAGI Bulletin d'Information*.

> It seems to me that the time has come when it is possible to direct all forces and means toward mutual efforts for creating an artificial satellite and to switch the military potential in the technology of rockets to the peaceful and noble purposes of developing cosmic flights. I think that such work would be an important contribution to the cause of eliminating the cold war and would serve the cause of consolidating peace.[120]

Again, Soviet announcements did not arouse much interest and went largely unnoticed.[121] Thus, as a result of widespread publicity given the U.S. effort as contrasted with the relative lack of attention paid the Soviet effort, the launching of Sputnik I was almost universally greeted with great astonishment and surprise. As expressed by Sullivan,

> In the consternation that ensued in the West, either it was forgotten that the satellite launchings were part of an international scientific effort or there was a strong feeling that the Russians had not played the IGY game according to the rules.[122]

This strong reaction to the news of Sputnik I was summarized by Walt W. Rostow, as follows:

> There is no clear analogy in American history to the crisis triggered by the launching of the Soviet earth satellite on October 4, 1957. This intrinsically harmless act of science and engineering was also, of course, both a demonstration of foreseeable Soviet capability to launch an ICBM and a powerful act of psychological warfare. It immediately set in motion forces in American political life which radically reversed the Nation's ruling conception of its military problem, of the appropriate level of the budget, and of the role of science in its affairs. The reaction reached even deeper, opening a fundamental reconsideration not only of the organization of the Department of Defense but also of the values and content of the American educational system and of the balance of values and objectives in contemporary American society as a whole.[123]

These reactions are discussed in greater detail below.

FEDERAL SUPPORT OF BASIC SCIENCE

The net effect of the IGY and Sputnik I on Federal support for basic science in the United States was unprecedented. Many effects were evident, including the restoration of Federal funds for scientific facilities that previously had been closed, strengthening of the Federal Government's in-house research efforts, and increased benefits for Federal scientists and engineers. Perhaps the most striking effect, however, was the change in appropriations for the National Science Foundation (NSF). Established by Congress in 1950, the NSF had "struggled through its first few years with appropriations far below even its fixed ceiling of $15 million." [124] By 1956, the NSF budget had increased to almost $30 million, about half of which, however, was specifically budgeted for IGY activities, as shown in table 5. Three years later, as pointed out by Berkner,

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[119] Senate, *Soviet Space Programs, 1966–70*, p. 160.
[120] See: Krieger, *Behind the Sputniks*, pp. 330–331.
[121] Senate, *Soviet Space Programs, 1966–70*, p. 160.
[122] Sullivan, "The IGY, p. 300.
[123] Walt W. Rostow, *The United States in the World Arena; An Essay in Recent History* (New York: Harper and Row, 1960), p. 366.
[124] *NSF–NAS Hearings: IGY Report*, p. 191.

> As a direct result of Sputnik, [the NSF's] 1959 appropriations total $130 million, certainly a radical recognition of the neglected importance of science and technology.[125]

Furthermore, the 1959 NSF budget was entirely devoted to Federal support of basic research; less than 5 percent, or only $6 million, represented formal IGY expense. By 1968, the NSF budget had peaked at over $500 million. As stated in a review of NSF activities, the IGY ". . . permitted the Foundation to support basic research to meet needs of science somewhat sooner than might have otherwise been possible." [126]

In retrospect, it is unfortunate that this increased Federal funding, and the considerable public interest in the IGY, were not translated into widespread public understanding and support of basic research. Unlike many of the activities of the IGY, which took place dramatically in remote and exciting areas of the globe, basic research was a difficult area of scientific activity for the general public to understand and appreciate, and still remains so. Although the IGY was, to scientists, primarily an exercise in basic research, to the public it appeared largely a matter of polar adventures and space satellites. Thus, were such an effort proposed today, it would appear doubtful that it would receive widespread public support unless the activities involved were sufficiently broadened so as to appeal to a wide variety of interests.

TABLE 5. BUDGET OBLIGATIONS OF THE NATIONAL SCIENCE FOUNDATION, 1951–72.[1]

Fiscal year	Basic NSF	IGY	Total	Percent IGY
1951	153			
1952	3, 466			
1953	4, 431			
1954	7, 962			
1955	12, 486	1, 837	14, 323	12. 8
1956	16, 068	14, 905	30, 973	48. 2
1957	38, 630	15, 037	53, 667	28. 0
1958	49, 973	19, 337	69, 310	27. 9
1959	132, 940	5, 932	138, 872	4. 3
1960	158, 600	1, 598	160, 198	1. 0
1961	174, 995	20	175, 015	----------
1962	260, 821			
1963	320, 754			
1964	354, 584			
1965	[2] 416, 000			
1966	[2] 466, 000			
1967	[2] 465, 000			
1968	[2] 505, 000			
1969	[2] 433, 000			
1970	[2] 461, 000			
1971	[2] 495, 000			
1972	[2] 598, 000			

[1] Figures in thousands of dollars.
[2] Figures rounded off to nearest thousand dollars.

Data for 1951–64 are taken from: U.S., Congress, House, Committee on Science and Astronautics, Subcommittee on Science, Research, and Development, The National Science Foundation: A General Review of Its 1st 15 Years, 89th Cong., 2d sess. Jan. 24, 1966, pp. 32–35. Data for 1965–72 are taken from: National Science Foundation, Databook NSF 73–3 (Washington: National Science Foundation, January 1973), p. 15.

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[125] *NSF–NAS Hearings: IGY Report*, p. 191.
[126] *NSF: Its First 15 Years*, p. 78.

THE SPACE PROGRAM

The launching of artificial earth satellites during the IGY, thereby initiating mankind's exploration of outer space, has frequently been characterized as the most significant result of the IGY. Berkner, for example, remarked that space research was perhaps " . . . the area of the IGY's greatest impact. For it was the IGY mechanism . . . which stimulated the first steps forward into space within the context of a peaceful, international program." [127] Similarly, Odishaw commented that the artificial satellite program of the IGY, representing a "striking departure" from the kinds of research techniques previously employed by scientists, might be the innovation that would determine "the ultimate place of [the] IGY in history." [128] Gerson observed that

> . . . the truly remarkable feature of the IGY [was] its boldness of execution in the space-age era. . . . Undoubtedly, the space age would have been launched by 1960–65 [but] the inclusion of satellite vehicles . . . in the IGY hastened [its] fruition.[129]

Sullivan commented that

> Under the auspices of the IGY the door to outer space has been opened. . . . The placement of the first space vehicles in orbits around the earth has marked the IGY as a momentous event in scientific history, comparable to the release of atomic power.[130]

More recently, in a report of the United Nation's Economic and Social Council, the role of the IGY in space research was summarized as follows:

> One of [the IGY's] projects was to have satellites circling the earth equipped with instruments to measure the earth's forces and the influences from outer space. From the original modest program in which the U.S.S.R. and the United States agreed to put small satellites into orbit emerged the space race, with cosmonauts and astronauts going first into orbit and then to the Moon, with rockets to Venus and Mars and the positioning of manmade satellites to reflect broadcast signals and make long-range television possible; to maintain day and night observations of the weather system and report back and in later refinements of detection to give a pattern of natural resources.[131]

Within the United States, the primary result of the Soviet achievement was the creation of the National Aeronautics and Space Administration (NASA), which was formed in 1958 "either directly or indirectly [as a result of] activities of the IGY." [132] As discussed by Sullivan, the IGY forced the Federal Government "to undertake a new function—that of large-scale exploration. It became necessary to form a new organ, the National Aeronautics and Space Administration, and to allocate to it an increasing share of the national budget." [133]

A corresponding response was evoked in the Congress. On March 5, 1958, the House Select Committee on Astronautics and Space Exploration was created, followed on July 21 by the establishment of the

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[127] *NSF–NAS Hearings: IGY Report*, p. 177.

[128] *NSF–NAS Hearings: IGY Report*, p. 22.

[129] Gorsen, "Polar Years to IGY," p. 44.

[130] Sullivan, "Scientific Alliance," p. 72.

[131] United Nations Economic and Social Council, *Science and Technology, Role of Modern Science and Technology in the Development of Nations and the Need to Strengthen Economic and Technico-scientific Cooperation Among States* (New York: United Nations ESC, Jan. 26, 1973), pp. 29–30. As of the present writing of course, only [U.S.] astronauts have succeeded in going to the Moon.

[132] Atwood, "The IGY in Retrospect," p. 689. See also remarks of Berkner in *NSF–NAS Hearings: IGY Report*, p. 191 and remarks earlier in this series in *Toward A New Diplomacy in A Scientific Age*, p. 7.

[133] Sullivan, *Assault*, p. 416. The increases in funds for space activities was discussed earlier in this series in the *Evolution of International Technology*, p. 16: "The most direct response [to Sputnik I] in the United States was an expansion in outlays for space activities. These virtually doubled in each fiscal year after Sputnik until 1961; they peaked at $7,688.5 million in 1966."

Committee on Science and Astronautics. In the Senate, the Special Committee on Space and Astronautics was created on February 6, 1958, followed on January 14, 1959, by establishment of the Committee on Aeronautical and Space Sciences. The National Aeronautics and Space Administration was established by passage of the National Aeronautics and Space Act of 1958, simultaneously creating the National Aeronautics and Space Council. Appropriations were passed funding both these and other space groups and activities. These moves effectively ushered both the legislative and executive branches of the Federal Government into the space age.

FEDERAL SCIENCE ADVISORY STRUCTURE

The launching of Sputnik I during the IGY resulted in radical changes in the Federal science advisory structure. Most important were the appointment of a Science Adviser to the President and the location of the President's Science Advisory Committee directly within the White House.[134] The latter step, according to Berkner, "has profoundly influenced all that has followed, for the needs of science, scientific research, and science education can now be understood and discussed at top governmental levels. Scientists finally have a definitive access to Government." [135] This much-expanded science advisory apparatus within the Executive Office in turn led to "the designation of a number of Assistant Secretaries for Science and Technology (or equivalent) in old-line departments." [136] This structure continued largely intact until it was dismantled by Reorganization Plan No. 1 of 1973.[137]

Additional effects were felt within the State Department, which in 1950 had created an Office of the Science Adviser and had appointed scientific attachés to several embassies in Western European countries. The Department's Science Office, which had been drastically curtailed in 1955, was revived and strengthened following Sputnik I. Science attachés, appointed to serve at U.S. embassies in London, Paris, Rome, Bonn, Stockholm, and Tokyo, were the first to serve under Wallace R. Brode, newly appointed as Science Adviser to the Secretary, and constituted the first of a series of such appointments following Sputnik I. Additional appointments to embassies in the U.S.S.R., India, and South American countries soon followed. The primary duties of the science attaché, according to the State Department, was

> . . . to serve as an adviser to the Ambassador and his staff in the evaluation of the interaction of science with foreign policy, the assessment of current scientific progress abroad, and the enhancement of the liaison between United States and foreign scientists and engineers.[138]

The fact that 24 countries had scientific attachés attached to their embassies in Washington attested to "the need and usefulness for representation of science in international affairs." [139] Transferred to the Office of the Science Adviser in May 1962 were several nonmilitary functions of the Space Affairs Section of the Office of the Special

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[134] These moves are discussed in detail by Atwood, "The IGY in Retrospect," p. 689, and in *NSF–NAS Hearings: IGY Report*, p. 191.

[135] Testimony of Berkner in *NSF–NAS Hearings: IGY Report*, p. 191.

[136] *Toward a New Diplomacy*, p. 7.

[137] Reproduced in: U.S., Congress, House, Committee on Government Operations, *Reorganization Plan No. 1 of 1973, Hearing*, 93d Cong., 1st sess., Feb. 26, 1973, pp. 97–104.

[138] *Department of State Bulletin* 39 (Dec. 29, 1959), pp. 1048–1049.

[139] *Department of State Bulletin* 39 (Dec. 29, 1959), p. 1049.

Assistant for Atomic Energy, established in 1957. This consolidated office ultimately became the present Bureau of International Scientific and Technological Affairs, one office of which is the Office of Space and Atmospheric Science Affairs.[140]

SCIENCE EDUCATION IN AMERICA

The IGY and Sputnik I, according to Sullivan, "precipitated a reexamination of the educational system and, in fact, of the entire American scale of values." [141] According to Senator Lyndon Johnson, then Senate Majority Leader, "We have lost an important battle in technology. That has been demostrated by the satellites that are whistling above our heads." [142] In a unanimous statement, the Senate Armed Services Preparedness Subcommittee declared: "We had expected to be first with this achievement. In fact, we have yet to prove second. . . . We are engaged in a race for survival, and we intend to win that race." [143]

Such concerns raised serious questions regarding the quality of science education in America and led to an analysis of the kind of education system necessary to "produce the well-informed and highly competent men of science and public affairs required if our Nation is to retain its position of responsibility and leadership in world affairs." [144] Congress requested the National Academy of Sciences to look into ways in which the IGY, as an undertaking of great public interest, could help to educate the public with regard to the value of science. The Academy responded by publishing the IGY bulletin and full-color educational posters on "Planet Earth," and by producing a series of 13 half-hour color films, one describing each IGY discipline.[145] As a result of these and other related IGY activities, parents, school boards, and legislators became more aware of the importance of science training for the Nation's youth.

Demands were voiced that highly qualified students be given better preparation for science careers. Curricula for secondary education were revised, and books by Conant, Rickover, and others sought to provide guidelines and stimulate discussion. Mathematics and science courses began to reappear in high schools on a substantial scale. Efforts were made to bring textbooks and teaching methods up to date as exemplified by the work on physics teaching by MIT and the revision of high school mathematics curricula by Yale. These and other efforts helped to stimulate a new, widespread interest in science in young people in schools and colleges throughout the country. Perhaps the greatest effect, however, was passage of the National Defense Education Act of 1958, which made available substantial Federal appropriations for these purposes.

In retrospect, this emphasis was not entirely beneficial. Science careers may have been made attractive to some students who lacked either the necessary qualifications or the sustained motivation required for such careers. Furthermore, as Dean Harvey Brooks has pointed out, curriculum reform was largely undertaken for the wrong reason, namely, ". . . on the grounds that it was needed to make our engineers and scientists better than their Soviet counterparts," rather than because of a fundamental desire to improve the way in which science was being taught.[146] Thus, while the Sputnik motivation increased interest in science and made changes easier, the danger also existed that both interest and programs might collapse once the motivation subsided.

PUBLIC ATTITUDES TOWARD SCIENCE

The impact of Sputnik I upon the American public was profound convincing Americans that they no longer possessed an undisputed lead over the rest of the world in science and technology. The Soviet accomplishment "caused a great deal of turmoil in the United States" and was "a real jolt to the complacency of the American people."[147] Unlike such previous Soviet successes as the atomic and hydrogen bombs, which Americans could rationalize as having been stolen from them through espionage, no such rationale was possible any longer. Furthermore, the large and shiny rocket that had propelled Sputnik I into the heavens was now circling the earth, clearly visible in the dark sky when illuminated by the rising or setting sun. Large numbers of Americans viewed this speck of light not only with awe, but with a shudder, recognizing the value of rocketry in warmaking.

Public attitudes were intensified by the extensive publicity given the Soviet achievement. As Chapman observed, "Never before was an international scientific enterprise made so widely known, by press and other publicity, to the parliaments and peoples of the world."[148] Detlev W. Bronk, then chairman of the National Science Board, declared that "The fact that . . . the newspapers of our country have given such a tremendous amount of space to the achievements of [the IGY] I think is evidence of the fact that they recognize that the imagination of the peoples of our country, the peoples of the world have been captured by this great adventure."[149] This widespread publicity and public interest, according to the National Science Foundation, made Sputnik I

> . . . a symbol of competition between Russian and American science, and a sign that we had "lost" a "scientific race." To the extent that the symbol became identified with such a "race," it was erroneous and destructive—we did not think of the undertaking in these terms, but regarded it as a part of a cooperative international scientific undertaking, the International Geophysical Year." [150]

This universal concern helped focus public attitudes upon the necessity for basic research, as well as its value. As stated further by the NSF,

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[140] Personal communication from Mr. Arthur E. Pardee, Jr., Executive Director of the BISTA.

[141] Sullivan, *Assault*, p. 415.

[142] Statement before the Senate Preparedness Investigating Committee. In: U.S., Congress, Senate, Committee on Armed Services, *Inquiry Into Satellite and Missile Programs, Hearings*, 85th Cong., 2d sess., 1958, p. 3.

[143] U.S., Congress, Senate, Armed Services Committee, Preparedness Investigating Subcommittee, *Hearings on Reports of the Secretary of Defense on Accomplishments of the Defense Department on Recommendations of the Preparedness Subcommittee*, 85th Cong., 2d sess., Jan. 23, 1958, p. 2427.

[144] *NSF Eighth Annual Report*, p. 5.

[145] *NAS IGY Program Report*, p. x.

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[146] Harvey Brooks, "Impact of the Defense Establishment on Science and Education." In: U.S., Congress, House, Committee on Science and Astronautics, Subcommittee on Science, Research, and Development, *National Science Policy. Hearings on H. Con. Res. 666*, 91st Cong., 2d sess., July, August, and September 1970, p. 962.

[147] See *The Evolution of International Technology*, p. 23.

[148] Chapman, "International Cooperation," p. 178.

[149] *NSF-NAS Hearings: IGY Report*, p. 4.

[150] *NSF Eighth Annual Report*, p. 3.

> Public discussions following the satellite launchings brought out once again the fact that Americans customarily think of science in terms of applied work, or engineering, despite the highly significant accomplishments of research workers in the areas of fundamental investigation. Nevertheless, the connection between basic and applied research, and the degree of dependence of the latter upon the former, has become increasingly clear during the past year.[151]

A nation of predominantly "practical" people, not overly concerned with "impractical" basic research, began to appreciate its value better as a result of the IGY.[152] Citizens became, according to Atwood, "more keenly aware of the contributions being made by scientists and by scientific institutions." [153] The leadership provided by the National Academy of Sciences brought it greater recognition, and the public became more aware of the value of the NSF and other scientific organizations, both public and private. The IGY also captured the imagination of children who, having lived always in an age of great scientific achievement, found artificial satellites less marvellous, miraculous, threatening, or unnecessary than did their parents. However, ". . . once the United States had begun to launch its own space vehicles there was an improvement in American attitudes, a thrill at witnessing the inception of a new era." [154]

COMMUNICATIONS SATELLITES

An important outcome of the IGY artificial earth satellite program was the development of international communications satellites. As pointed out by Ambassador Abbott Washburn, chairman of the U.S. delegation to the INTELSAT Conference in 1971:

> After the first artificial earth satellite was launched in 1957, orbiting satellites for communications moved rapidly from theory to practical reality.[155]

Progress was facilitated because the potential usefulness of earth satellites for communications purposes had been widely discussed and the theory of their application was relatively well developed. At a sufficiently high altitude, individual satellites each can relay microwave signals directly to more than one-third of the earth's surface, reaching remote and less accessible areas as well as major world centers of economic and political power. The Communications Satellite Corporation (COMSAT) was organized in 1963 as a result of the 1962 Communications Satellite Act to represent the "chosen instrument" of the United States in bringing commercial satellite communications to the world. The International Telecommunications Satellite Consortium (INTELSAT) was created by interim international agreement in 1964 to provide an international mechanism through which a single, unified, global commercial communications satellite system could be operated. Permanent arrangements for INTELSAT were completed after much negotiation during 1968–71 and entered into force on February 12, 1973, providing the world with ". . . the first peaceful use of outer space for everyday commercial purposes." [156]

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[151] *NSF Eighth Annual Report*, p. 4.

[152] Kaplan, "What We've Learned," p. 13.

[153] Atwood, "The IGY in Retrospect," p. 688.

[154] Sullivan, *Assault*, p. 2.

[155] Ambassador Abbott Washburn, "The International Telecommunications Satellite Organization," in: *International Cooperation in Outer Space: A Symposium*. U.S., Congress, Senate, Committee on Aeronautical and Space Sciences, *Senate Document No. 92-57*, 92d Cong., 1st sess., Dec. 9, 1971, p. 437. Much of the material in this section is summarized from Washburn, pp. 437–452.

[156] Ibid. For additional information concerning the interim and definitive Intelsat agreements, see: *Treaties and Other International Acts Series*, Nos. 5646 and 7532, respectively.

EFFECT ON NATIONAL DEFENSE

As previously discussed, the size of the initial orbiting sputniks (180 pounds for Sputnik I and 1,120 pounds for Sputnik II) made it immediately evident that the Soviets possessed rockets capable of traversing intercontinental distances with quite heavy payloads. Concern was expressed that this Soviet capability might lead to a race to produce military space vehicles at the expense of scientific space research.[157] Although research did not flag, U.S. efforts to develop long-range missiles were greatly speeded up, no doubt leading to further efforts on the part of the Soviets. To promote U.S. efforts, the position of Director of Research and Engineering was established within the Department of Defense, ranking above the Assistant Secretaries of Defense and possessing the authority to manage interservice projects without following the normal military chain of command. He was supported by an Office of the Director of Defense Research and Engineering, as well as by the Advanced Research Projects Agency. In addition, some parts of the DOD were reorganized to permit "a more intelligent treatment of some of our most urgent and difficult defense problems." [158]

Sputnik I also led to a revoking of the initial decision to use only nonmilitary rockets in the American IGY artificial satellite program. The great weights of the Sputnik satellites made it clear that Soviet IGY scientists, far from being required to develop their own rocketry, were being furnished with the U.S.S.R.'s most powerful military hardware. The effect of this knowledge, coupled with a succession of failures of the Vanguard program, was to establish a parallel satellite program in which the U.S. Army took responsibility for the launchings. This decision resulted in the successful orbiting of the highly useful Explorer satellites.

EFFECT ON FOREIGN POLICY

The IGY, according to Atwood, "further demonstrated the significance of scientific factors in formulating and executing foreign policy," particularly as evidenced in the daily activities of the State Department and pronouncements of other Federal agencies. With its associated scientific and technological achievements, the IGY "clearly indicated that science could facilitate the attainment of peaceful objectives of foreign policy." [159] Certainly the IGY engendered unprecedented international cooperation and good will, at least on the part of scientists. The extent to which this rapprochement was effectively utilized as a tool of U.S. foreign policy is difficult to assess and is discussed later.

International Impacts

International impacts of the IGY and the orbiting of the first sputniks were every bit as spectacular as were the impacts upon the United States and would be difficult to exaggerate. Foremost was the impact upon the cold war. Tensions heightened in East-West relations as the Soviet leadership sought to use its success in space to further its goals in foreign and military policy and as the United States countered Soviet thrusts with crash programs in space and missile development. Sputnik I catalyzed the cold war and not until the aftermath of the Cuban missile crisis 6 years later were Soviet-American leaders able to take the first steps decelerating the spiralling pressures of the arms race. Additional impacts were the effect upon the international politics of science, the use of science as a vital element in foreign affairs, and the generation of a remarkable degree of international cooperation and good will in politically nonsensitive pursuits.

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[157] Sullivan, "Scientific Alliance," p. 72. As noted earlier in *The Evolution of International Technology*, the Soviet achievement "erased the issue of the 'Bomber Gap' [and] created a 'Missile Gap' " (p. 24).

[158] *NSF-NAS Hearings: IGY Report*, p. 192.

[159] Atwood, "The IGY in Retrospect," p. 689.

THE EFFECT ON INTERNATIONAL SCIENCE

The impact of the IGY upon the politics of world science was considerable. Although international scientific adventures had taken place before the IGY (as discussed in section II of this study), none had approached the IGY in magnitude. As stated by Gerson, the physical entirety of the IGY was almost majestic, the number of participating nations was impressive, a veritable army of scientists were deployed, the number of participating stations exceeded all expectations, and the cost was astronomical.[160] It was thus inevitable that the IGY should exert considerable influence upon the future conduct of international science.

A major influence was the strengthening of old ties among scientists and the forging of many new ones. The previous system of somewhat limited bilateral cooperation in developing and exchanging information was replaced by true international cooperation in coordinated and continuing investigations. Methods developed so successfully by the ICSU and its various unions during the IGY were seen as ideally suited for the furtherance of international cooperation in science, and suggestions were made that these methods should be emulated in the future and used in other scientific areas.

International organizations like the ICSU and its member nations were considerably strengthened by their roles in the IGY, and thus subsequent efforts were made easier. For example, Sullivan commented that the ICSU, "largely because of the IGY . . . emerged as the world's supreme non-governmental organ in science."[161] The Soviet rocketry and space scientist, previously leading "a solitary life in his cloistered laboratory cut off from the world scientific community," regained contact with the Western world.[162] Furthermore, Western scientists gained a deeper appreciation of the quality and value of the work of their Soviet counterparts. The IGY also served to stimulate, on a world wide basis, the interdisciplinary approach to problem solving. Finally, the IGY helped to spur the revival of science in underdeveloped nations newly experiencing their independence, and facilitated the reopening of major scientific facilities like observatories which had been closed when vacated by scientists returning to their native countries.

Significantly, the IGY legacy also includes formative influences upon entirely new, governmentally sponsored programs which frequently use as models corresponding programs which had been developed during the IGY and then continued after the expiration of the IGY and the IGC–1959 (discussed in section IV). One of these

new programs was the international years of the quiet sun (IYQS), held from January 1, 1964, through December 31, 1965, which was organized in much the same fashion as was the IGY but was geared for a period of relatively quiet solar activity.[163] Another was the upper mantle program, held in 1966–70.[164] Other new programs included the global atmospheric research program, the international geodynamics project, the international magnetosphere survey,[165] the world weather watch, Indian Ocean research, and the international biological program. Typical of the long-lasting effects of the IGY is a reference appearing in a 1966 Senate report giving credit to the IGY and the IGCC for providing the impetus to the Soviet use of meteorological rockets that is still being felt.[166]

It is worth noting here that the scientific leadership of the IGY was largely composed of a distinguished elite having considerable influence within their respective countries. The IGY was effective in helping to consolidate these various national elites into an international elite, the influence of which has not been confined, over the years, to purely scientific matters. Thus, the effect of the IGY on both international science and political affairs upon which international science depends, is doubtless still being felt in many areas today.

SCIENCE IN FOREIGN AFFAIRS

Given the wide-ranging character of the IGY in international scientific affairs, it was natural for hopes and expectations to be raised regarding the ability of scientists to function as international diplomats. Their possible success in doing so is difficult to evaluate, but it seems reasonable to assume at least a certain degree of effectiveness. Sullivan has remarked that "The IGY's construction of scientific bridges across political chasms coincided with a general growth of science's role in diplomacy, as well as in national policymaking." He further points out that "Russian academicians, many of them bearers of a venerable humanistic tradition, had reestablished contact with the Western World and had shown the extent—and limitations—of their influence on Soviet policy."[167] George B. Kistiakowsky, science adviser to President Eisenhower, has pointed out that, in terms of its potential impact on political relations, participation in international scientific activities like the IGY remains perhaps the most important role that can be played by scientists today:

> For science is today one of the few common languages of mankind; it can provide a basis for understanding and communication of ideas between people that is independent of political boundaries and of ideologies. Science also provides a sometimes unique opportunity for cooperative endeavors that can contribute in a major way to the reduction of tension between nations and, more positively, to close relations between the United States and other countries.[168]

Sullivan speculates that the IGY "could prove, from the perspective of the future, to have been a turning point in the history of mankind—

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[160] Gerson, "Polar Years to IGY," p. 44.

[161] Sullivan, "The IGY," p. 331.

[162] Senate, "Soviet Space Programs: Organization [etc.]," p. 23. The role of the Soviet scientist is also discussed by Sullivan in: "The IGY," p. 327.

[163] For a discussion of the IYQS, see: U.S., Congress, Senate, Committee on Aeronautical and Space Sciences, *International Cooperation and Organization for Outer Space, Document No. 56*, 89th Cong., 1st sess., Aug. 12, 1965, pp. 95–97, 375; and U.S., Congress, Senate, Committee on Aeronautical and Space Sciences, *Soviet Space Programs, 1962–65; Goals and Purposes, Achievements, Plans, and International Implications*, 89th Cong., 2d sess., Dec. 30, 1966, pp. 627–633.

[164] National Academy of Sciences, *Physics in Perspective*, vol. I (Washington: National Academy of Sciences, 1972, p. 569.

[165] NAS, *Physics in Perspective*, p. 509.

[166] *Soviet Space Programs, 1962–65*, p. 229.

[167] Sullivan, *Assault*, pp. 415, 417.

[168] George B. Kistiakowsky, "Science and Foreign Affairs," *Bulletin of the Atomic Scientists* 16 April (1960), p. 115.

the start of a period in which scientists assumed a greater role in helping to solve international problems." [169] Atwood similarly expressed the belief that the IGY helped open many eyes to the significance of science in world affairs.[170] Undoubtedly it helped make possible further participation of scientists in "unofficial, exploratory investigations of possible future diplomatic opportunities," including such ventures as the Pugwash conferences.[171] Although the diplomatic consequences of these international contacts are difficult to evaluate, they appear to be significant. In Sullivan's view, one cannot "separate the IGY from the growth of science's role in diplomacy during 1957 and 1958." [172]

On a largely political scale, the rocketry and outer space activities of the IGY provide an excellent example of the role of a scientific program in the conduct of foreign affairs. On the surface, the early space activities were purely scientific endeavors, aimed at the exploration of natural phenomena high above the earth's atmosphere. However, Mr. Arnold W. Frutkin, Director of Information for the USNC during the IGY, has expressed the belief that the Soviet IGY space program had primarily political rather than scientific objectives.[173] His view conforms with the widespread agreement that still appears to exist in the West that "An important governing principle in the Soviet system of research and development is the close interrelationship of science, technology, and military affairs." [174] In keeping with this view, it is maintained that

> . . . the Russians have approached space exploration not only as a strictly technical matter but as an important component of politics, both national and international. For them space is only one part of a much larger political ideological effort, namely, to achieve the historically determined goals of communism.[175]

More recently Frutkin, speaking as Assistant Administrator for International Affairs, NASA, pointed out that, particularly with respect to the Apollo-Soyuz test project, Soviet cooperation with the United States in peaceful activities for outer space has greatly accelerated since 1969.[176] This cooperation has also resulted in agreement

> . . . for the exchange of lunar samples, for exchanges of scientific results and objectives for certain coordinated scientific activities, and on procedures for recommending additional cooperation in space science and applications.[177]

This cooperation, says Frutkin, is ". . . more than a pleasant and useful gesture in an era of political accommodation," but in addition should ". . . point the way to future joint activities which should help both countries gain more in space than they would from separate programs." [178]

However, the Soviets are by no means unique in this respect. Although an exact parallel cannot be drawn between Soviet and American attitudes, nonetheless, a strong relationship exists also between the U.S. research and development community and the Department of Defense, and Americans are not immune from exploiting their scientific

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[169] Sullivan, "The IGY," p. 259.

[170] Atwood, "The IGY in Retrospect," p. 689.

[171] *Toward A New Diplomacy*, p. 21.

[172] Sullivan, "The IGY," p. 334.

[173] Arnold W. Frutkin, "The Character of International Cooperation in Space," address before the American Rocket Society during its symposium, *Space Flight Report to the Nation*, Oct. 9–15, 1961. See: *Soviet Space Programs: Organization, etc.*, p. 177.

[174] Senate, *Soviet Space Programs: Organization*, [*etc.*], p. 177.

[175] Senate, *Soviet Space Programs, 1966–70*, p. 53.

[176] U.S., Congress, Senate, Committee on Aeronautical and Space Sciences, *NASA Authorization for Fiscal Year 1974, Hearings on S. 880, pt. 2*, 93d Cong., 1st sess., Mar. 22, 1973, p. 1368.

[177] Senate, *Hearings on S. 880*, pp. 1368–1369.

[178] Senate, *Hearings on S. 880*, p. 1369.

accomplishments politically. The Soviets, it is claimed, maintain in "what has come to be a fairly traditional propaganda line . . . that the United States uses space for military purposes." [179] The difference, it is said, is that "the United States has never denied that it has military space programs [whereas] the Soviets, seeking to maintain their propaganda image as a 'peaceful' user of outer space, have, in contrast, never made such admissions." [180] Furthermore, it is stated that the Soviets have attempted to link "the militarization of space with other foreign policy issues," including American involvement in Vietnam.[181]

Thus, space exploration, although in essence primarily a scientific and technological enterprise, inevitably is deeply involved in current international politics. Space politics has become a matter of major concern between the two great space powers, as a result of decades of rivalry and confrontation. [182] The Soviet Government, on the one hand, is said to see limited reason for cooperating only in those areas which can (1) pay off in military strength, or (2) promise opportunity for spectacular developments politically useful in shaping world opinion. [183] Space exploration has provided the Soviets with a unique instrument for achieving this political purpose of reaffirmation through glorification; that is, using the glory derived from success in space to reaffirm the legitimacy of the party and the state.[184] Space triumphs

> . . . have been used to affirm the glory of the Communist Party and the Soviet state . . . [and] have been attributed to the workings of the Soviet system. The foundations of the space program have been tied to Lenin and Leninism. The pride in space accomplishments has been seen as a way of raising citizen morale, and the resulting prestige of space successes has been exploited for what political value it had.[185]

The United States, on the other hand, has generally sought to prevent such total subjugation of its space activities to national and international politics. In recent years as Soviet-American relations have shifted gradually from confrontation to negotiation, as the cold war has been appreciably decompressed, as American space activities have far outdistanced Soviet efforts, and as a nuclear balance has been achieved, rivalry in space has been reduced to the extent that joint Soviet-American space flights are now in the realm of the possible. Thus, the efforts begun during the IGY appear at last to be promoting the kind of cooperation and good will hoped for by so many nearly two decades ago.

INTERNATIONAL COOPERATION AND GOOD WILL

Participants in the IGY, although scientists keenly aware of its major scientific value, have nonetheless frequently been moved to claim that the most valuable benefits of the IGY were not scientific, but were those derived from the generating of international cooperation and good will. Atwood, for example, has stated:

> I think that it is fair to say that the international significance of the program, as its name bears out, has been of greater significance than even the very important discoveries which have been made. At a time when we are torn asunder by

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[179] Senate, *Hearings on S. 880*, p. 43.

[180] Senate, *Hearings on S. 880*, pp. 43–44.

[181] Senate, *Hearings on S. 880*, p. 44.

[182] Senate, *Hearings on S. 880*, p. 1.

[183] Senate, *Soviet Space Programs; Organization*, [*etc.*], p. 175.

[184] Senate, *Soviet Programs, 1966–70*, p. 15.

[185] Senate, *Soviet Space Programs, 1966–70*, p. XXI.

> ideological differences and by selfish national attacks upon the freedom we stand for, it is heartening to find that there are some things that people can do together with common amity.[186]

Somewhat similar sentiments were expressed by Tuve:

> Perhaps the most important result of the IGY is the demonstration that the people of the Earth, despite their differences, can get together and work with complete wholeheartedness in studying things which are of concern to all of us and which could be of great nationalistic value if they were emphasized from a selfish point of view.[187]

To participants, this international cooperative fellowship appears to have been a constant source of unexpected pleasure and, to observers, a constant source of amazement and surprise. Odishaw, a participant, remarked how the IGY succeeded brilliantly in marshaling international cooperation.[188] Roberts, another participant, remarked:

> As a result [of the IGY] we have new and powerful ties on an individual level between leading scientists of many lands, mounting understanding for one another, a great breach in the Iron Curtain, and a demonstration that men of many races and political faiths can work together fruitfully. Even if these accomplishments cannot be exactly evaluated, their meaning for the world is deep and pervasive.[189]

Wilson, also a participant, commented that:

> It is perhaps not unreasonable to maintain that the greatest achievement of the IGY lay not in its remarkable technical advances, but in the demonstration that scientists are good humanists, for they successfully organized a small but complex segment of society which worked [and thus] helped achieve a better balance between humanism and science.[190]

Chapman called the IGY the greatest example of worldwide scientific cooperation in the history of our race,[191] and to Berkner the Antarctic program of the IGY represented international collaboration of the highest type.[192] These expressions of gratification on the part of scientists reflected their pleasure in the IGY as an international scientific undertaking that had exceeded even their greatest expectations both scientifically and diplomatically. But in a larger sense, underlying these expressions, and sometimes openly voiced, was the further expectation or hope that this immense spirit of cooperation and goodwill could somehow be caused to flow unimpeded into the political arena, there to ease the political tensions so prevalent at the time, and promote peaceful coexistence among diverse political powers. The extent to which these hopes were met is discussed next.

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[186] *NSF-NAS Hearings: IGY Report*, p. 3.
[187] *NSF-NAS Hearings: IGY Report*, p. 65.
[188] *NSF-NAS Hearings: IGY Report*, p. 20.
[189] Roberts, "The IGY in Retrospect," p. 263.
[190] Wilson, *New Moons*, pp. 327–328.
[191] Sullivan, "The IGY," p. 283.
[192] Lloyd V. Berkner, "The International Geophysical Year, 1957–58: A Pattern for International Cooperation in Research," *Proceedings of the American Physical Society* 101 (Apr. 19, 1957), p. 160.

VI. ANALYSIS AND DISCUSSION

The specific questions addressed by this study are simple: does evidence exist that the tremendous spirit of international cooperation and good will generated by the IGY was to any extent successfully transferred from the scientific to the political arena? Can it be said with any confidence that the techniques so successfully employed by IGY scientists in dealing with one another to solve problems of common interest are at all applicable to political behavior?

The discussion which follows suggests that a reasonable case can be made for the observation that at least some degree of cooperative spillover occurred; that is, that certain subsequent international political agreements were furthered by the climate created, in some instances many years earlier, by the IGY. After considering the scientific good will which was mainly responsible for the cooperative successes of the IGY, this section concludes with a brief discussion of three such agreements.

Scientists as Eternal Optimists

The participants in the IGY were primarily physical scientists, largely concerned with the study and control of scientific phenomena rather than with the conduct of human society. They may therefore be excused their apparent naivete in voicing expectations that the cooperative spirit and techniques they developed so successfully in dealing with each other as scientists might work equally well in dealing with one another as social and political creatures. The *esprit de corps* engendered by the IGY appears to have replaced natural human conservatism, and expressions of optimism flowed freely in the aftermath of that spectacular scientific activity. Wilson, for example, observed that

> . . . the International Geophysical Year brought many men together under conditions that tended to create harmony and sympathy between them [and] showed that scientists could play a fruitful role in international negotiations and could strengthen international organizations such as ICSU and its parent body UNESCO . . . .[193]

These and other joint efforts by scientists, he maintained, must be extended to include the control of nuclear fission and the problem of an increasing population; or we are lost.[194] Berkner pointed out that:

> Even more than nuclear energy, the satellite has symbolized the cohesive force of science in bringing together and cementing political, social, and economic elements of man's civilization.[195]

Chapman suggested that:

> The harmonious development and execution of the IGY enterprise set a pattern that might serve as an example to be emulated in more difficult, political fields.[196]

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[193] Wilson, *New Moons*, pp. 325, 328.
[194] Wilson, *New Moons*, p. 328.
[195] Berkner, "Geography and Space," p. 306.
[196] Sydney Chapman, "Earth and Beyond: The International Geophysical Year in Retrospect. Was It A 'Turning Point in History?,' " *Science* 133 (July 7, 1961), p. 41.

Atwood commented that "As a consequence, peaceful cooperation among people of all nations is a little closer to realization," and expressed the hope that "the United Nations and its specialized agencies . . . will call upon organizations such as ICSU for advice and assistance." [197] Similarly, Kistiakowsky remarked on the potential role of science in international affairs:

> The significance of international scientific activities to the relations between nations is perhaps the most important of the roles science and scientists can play in today's embittered and divided world—not a new role in the sense that international activities of science are part of the lifeblood of science; but new in its potential impact on political relations.[198]

Perhaps not surprisingly, the optimism of the scientific community spread to nonscientists as well. On the eve of the IGY, Prince Philip, the Duke of Edinburgh, in a television interview remarked:

> The IGY is the world studying itself. It is seldom that this world of ours acts together. . . . Yet, for the next 18 months, east and west, north and south, will unite in the greatest assault in history on the secrets of the earth. . . . At the same time, it may well help to solve the real problem—the conflict of ideas.[199]

Representative Albert Thomas, while chairing a subcommittee of the House Appropriations Committee, commented:

> I think you gentlemen of the International Geophysical Year have set a pattern of worldwide cooperation that nations and governments, and particularly our good State Department, can take a leaf out of your book.[200]

And Walter Sullivan, having served as a full-time observer of the IGY for the New York Times, expressed the hope that the efforts of scientists, as exemplified by the IGY, might "provide a meeting ground where East and West can find mutually acceptable techniques for disarmament." [201]

These comments represent a cross-section of the frequent direct or indirect exhortations to politicians to employ in their political affairs the techniques of science and scientists. Implicit in these exhortations is the notion that political problems are amenable to scientific principles, properly applied. Refreshing as the intent underlying such beliefs may be, it nonetheless underestimates the formidable differences existing between the scientific and political communities.

Scientific vis-a-vis Political Good Will

One of the difficulties in attempting to transfer scientific methodology into political reality is suggested by Sullivan's observation that "science, in treating our planet as indivisible, is far ahead of politics, which treats it as two worlds." [202] In view of today's multiple ideologies, "multiple worlds" might be a more appropriate political designation. During the IGY, as a result of their common participation in efforts which opened up to man not only Antarctica but outer space, scientists were said to have experienced unusually strong feelings of humility and brotherhood.[203] These feelings served to reinforce the traditional attitudes most natural scientists develop as a result of sharing with others the common objective of unveiling nature's secrets. There is but one universe for scientists to study, and its singularity unites all scientific minds.

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[197] Atwood, "The IGY in Retrospect," p. 689.
[198] Kistiakowsky, "Science and Foreign Affairs," p. 114.
[199] *Illustrated* (London), July 27, 1957, pp. 26–27.
[200] *NSF-NAS Hearings: IGY Report*, p. 20.
[201] Sullivan, "The IGY," p. 260.
[202] Sullivan, "Scientific Alliance," p. 68.
[203] Wilson, *New Moons*, p. 325.

Traditionally, cooperation in solving scientific problems has always appeared immeasurably less complex than cooperation in solving political problems. As pointed out by Astin, since—

> . . . science is concerned with external phenomena which are usually measureable and whose manifestations are demonstrable and repeatable, there is less cause for disagreement, for controversy, than there is . . . in politics . . . . Furthermore, the preoccupations of . . . scientists are usually less charged with emotion than are those of . . . politician[s] . . . . The consideration of political . . . plans or policies tends to arouse . . . passions, whereas deliberations [on scientific matters] tend to proceed more calmly.[204]

Thus scientists tend to have fewer social problems since their research is generally focused upon common, well-defined objectives offering "a natural point of convergence, namely, the correct result." [205] Unlike politicians, they are not engaged in conflict resolution as a profession and are not charged with responsibility for the protection of national interests in a competitive arena. Rather, the existence of a common, agreed-upon technical objective creates a tendency toward social cooperation despite all obstacles, a tendency which has become a characteristic of the international scientific community.[206] Scientists tend inherently to recognize the interdependence of their efforts and accept that interdependence as one of the basic conditions of the environment in which they work. It is then relatively easy for them to accept the extension of this principle to the environment in which they live.

Despite these inherent advantages scientists possess over their political brethren, some pitfalls persist. It is possible "to interject political considerations into scientific and technical discussions so that a consensus of opinion can deliberately be prevented from emerging into a group decision." [207] This appears to have occurred during the IGY when the Soviets made agreement impossible on what kinds of launch and telemetering data would be provided to all participants.[208] In general, however, such behavior tends to be minimized among scientists because of their overriding concern for success of the project itself. Scientists appear unusually skilled in finding "common denominators which enable them to cooperate in attaining generally desired objectives." [209]

In view of the substantial differences between the scientific and political communities in the kinds of problems they are respectively called upon to solve, prudence would suggest caution in looking for too bold a transfer of techniques from one community to another. The IGY itself was apolitical and closed-ended, whereas the political process is, *a priori*, political and open-ended.[210] Yet, politicians and scientists do share some important human characteristics. Politicians and governments, no less than scientists and scientific organizations, are capable of and motivated toward uniting to achieve common objectives. A major difficulty is that the procedures for finding solutions to problems facing politicians and governments are less clearly defined than are the procedures for finding solutions to the specific types of problems commonly faced by scientists and engineers.

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[204] Astin, "The Scientific Community," p. 32.
[205] Senate Document No. 56, *International Cooperation and Organization*, p. 208.
[206] Astin, "The Scientific Community," p. 32.
[207] Senate Document No. 56, *International Cooperation and Organization*, p. 209.
[208] Discussed in detail in: Arnold W. Frutkin, *International Cooperation in Space* (Englewood Cliffs: Prentice Hall, 1965).
[209] Senate Document No. 56, *International Cooperation and Organization*, p. 209.
[210] Comment by Murray Todd, executive director, Office of the Foreign Secretary, National Academy of Sciences.

Scientific and engineering problems are typically more specifically defined than are political problems, which tend to be overburdened with value systems in which rational and irrational factors are intermixed. Nonetheless, if men can unite to solve problems under one set of circumstances (the scientific), there presumably is room for hope that they can learn to do so under another (the political). Scientists, as already indicated, tend to share this hope.

Several factors help provide at least some degree of optimism that the scientists may be justified. One is the great importance of first perceiving and assessing, and then communicating, technological impacts. Scientists and technologists are likely to comprehend the possible consequences of new discoveries and applications in the fields of energy or of ecology, for example, more immediately or fully than are politicians. Partly because of the IGY, both technological developments and political (or institutional) developments which significantly affect the human condition can be more readily appreciated and utilized today. First, they can be brought to the attention of both political leaders and the public within countries (it is becoming increasingly difficult for leaders to withhold them even in dictatorships); secondly, they can be shared among the countries of the world far more readily than was possible just two or three decades ago. Wider public understanding of technological impacts and a stronger institutional framework (governmental, professional, and the press) for increasing that understanding still further are in large part responsible in the first instance; technological advances in rapid communications and transportation are among the factors responsible in the second.

More effective communication does not necessarily serve the interests of peace and stability; it can be used to increase strife and tension. Even well-intentioned communication could conceivably do more harm than good, as by inducing excessive anxieties. In general, however, the friendly (or at least nonhostile) communicating, both within and among countries, of knowledge relating to human survival on earth is a responsibility which cannot be evaded by the present generation. Scientists and politicians have an obvious common interest in meeting that vital challenge; scientists, again, are likely to be the first to perceive it in specific forms. Moreover, as Wilson has pointed out, "The dangerous tensions that can so easily be . . . generated between nations can best be resolved by friendly communication." Such communication can first be initiated with subjects like science "for which standards of excellence are universally accepted and applicable across national barriers."[211] As long as scientists continue to talk to one another without regard for national boundaries, hope exists that diplomats from various nations (whose very business is communicating) may also begin to speak to one another in similar fashion, raising their sights and their expectations of accomplishment. It is not unreasonable to suggest that, in view of the enormous scope of the IGY and the number of scientists involved, the example set by discussion of scientific problems may well have provided some impetus for undertaking significant political discussions as well.

A factor of growing importance and urgency is the universal need for cooperation in solving problems. No better example of international cooperation exists than the IGY which, as pointed out by

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[211] Wilson, *New Moons*, p. 325.

Wilson, "provided an example of how international agreements can be made to work smoothly."[212] Astin has commented that "valid and important scientific goals can lead governments away from narrow nationalistic rigidities toward free and constructive international cooperation."[213] Although these comments may tend to oversimplify the transfer process, implicit in them is the recognition that, having agreed once in one area, it is easier for human beings to move forward toward agreement in another area than had there been no original agreement at all. Agreements made during the IGY were sufficiently widespread and long-lasting as to make plausible the possibility that their consummation helped contribute to eventual agreements in political areas.

Still another factor is that of common understanding, without which agreement in any area is impossible. Berkner has remarked that the

> . . . rule of law among nations will not be achieved until men are bound together by common threads of cultural understanding. Certainly science is one of those threads—perhaps a major line that permits men to speak to one another with comprehension, confidence, and common purpose. Coming in times of international tension, the IGY was a clear demonstration of the power of such cultural bonds.[214]

Thus the IGY, in helping to ameliorate international tensions and spread good will, provided "a common meeting ground and a common goal for nations that disagreed on about all else."[215]

International Diplomacy and the IGY

As indicated earlier, the specific objective of this study is to determine to what extent, if any, the IGY contributed to international diplomacy by opening up new communication channels, stimulating cooperation, and promoting increased understanding among the 67 nations that participated jointly in its activities. A review of the circumstances suggests that these factors may have contributed substantially to at least three major diplomatic achievements: the 1961 Antarctic Treaty, the 1963 Test Ban Treaty, and the 1967 Space Treaty.[216]

THE ANTARCTIC TREATY

Perhaps no better example exists of the direct effect of scientific affairs on international diplomacy than the Antarctic Treaty, of which the first sentence of article I states, "Antarctica shall be used for peaceful purposes only."[217] As a result of this agreement, "a whole continent on this planet was, for the first time in man's history, reserved as a universal laboratory for one and all, whoever desires to freely pursue scientific investigation for peaceful purposes."[218] This remarkable event, unprecedented in international politics, is generally agreed to have resulted directly from IGY activities in Antarctica. Chapman, for example, stated that the IGY led to the drafting of the Antarctic Treaty that aims to exclude military action from Antarctica,"[219] and Sullivan commented, "The stated objective of the proposed treaty was to perpetuate the cooperation that had marked the IGY in Antarctica."[220] Indeed, the IGY is mentioned twice in the treaty itself:

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[212] Wilson, *New Moons*, p. 325.

[213] Astin, "The Scientific Community," p. 34.

[214] Remark by Berkner in his introduction to Wilson, *New Moons*, p. ix.

[215] Gerson, "Polar Years to IGY," p. 43.

[216] Exact titles of these agreements and the dates when they entered into force for the United States are as follows: The Antarctic Treaty, June 23, 1961; the Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space, and Under Water, Oct. 10, 1963; and the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Oct. 10, 1967. From: U.S. Department of State, *Treaties in Force: A List of Treaties and Other International Agreements of the United States in Force on Jan. 1, 1973.* State Department Document No. 8697 (Washington: U.S. Government Printing Office, no date), pp. 284, 357, 386.

[217] The complete text of the treaty appears in: *The Conference on Antarctica, Department of State Publication 7060, International Organization and Conference Series 13* (Washington: U.S. Government Printing Office, September 1960), pp. 61–67. See also: TIAS No. 4780.

[218] Doumani, "Science Policy for the Antarctic," p. 40.

> Convinced that the establishment of a firm foundation for the continuation and development of such cooperation on the basis of freedom of scientific investigation in Antarctica as applied during the International Geophysical Year accords with the interests of science and the progress of all mankind [preamble];
>
> Freedom of scientific investigation in Antarctica and cooperation toward that end, as applied during the International Geophysical Year, shall continue, subject to the provisions of the present treaty. [art. II].[221]

Antarctica, for many decades prior to the IGY, had been an object of continued interest and investigation to many nations. Of these, seven had established territorial claims upon the continent, some of which overlapped.[222] As early as 1948 the United States, which officially recognized no claims, had proposed an international solution to other claimants, but without success. Similar efforts by India in 1956 before the United Nations General Assembly also met with no success, ostensibly being shelved to avoid controversy during the IGY; and discussions of the problem by Australia, New Zealand, and the United Kingdom also led nowhere. Thus, throughout the IGY the status of Antarctica was not only politically unresolved, but remained an issue of political controversy.

This controversy, by and large, did not significantly affect relationships among scientists carrying out work in Antarctica during the IGY. The general apolitical tone of this activity was set quite early during the first IGY regional conference on the Antarctic held in Paris during July 6–10, 1955. As noted by Sullivan, a somewhat awkward situation existed at this meeting because both the Chilean and Argentine delegations were headed by ambassadors rather than by scientists. However, the forcefulness of the chairman of the meeting "was unquestionably responsible for subduing the political controversies that repeatedly seemed about to erupt."[223] Subsequent scientific activities in the Antarctic demonstrated convincingly that scientists of various countries, including those having overlapping Antarctic claims, could work peacefully together, relatively unaffected by the unresolved political difficulties. That they could do so was due partly to common scientific objectives and partly to the forbidding nature of the area. As Sullivan commented:

> The stark, perilous environment of Antarctica had a remarkable effect in submerging political differences. The expeditions there were bound together by the presence of a common enemy.[224]

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[219] Chapman, "Earth and Beyond," p. 41.

[220] Sullivan, "The IGY," p. 326.

[221] Department of State, *Conference on Antarctica*, pp. 61–62.

[222] The seven nations were Argentina, Australia, Chile, France, New Zealand, the United Kingdom, and (unofficially) the United States. The overlapping claims were those of Argentina, Chile, and the United Kingdom.

[223] Sullivan, "The IGY," p. 320.

[224] Sullivan, *Assault*, p. 413.

An additional factor was that scientists were not personally responsible for protecting their respective national interests in the area, since such interests were not at stake in the IGY.

It was clear to all nations involved that much could be gained if the scientific work begun during the IGY could be continued thereafter. On May 2, 1958, the United States proposed to other participants that all should join "in a treaty designed to preserve the continent as an international laboratory for scientific research and insure that it be used only for peaceful purposes."[225] All accepted, but preliminary talks in Washington were largely stalled by Soviet opposition to existing Antarctic claims of other nations, and by Chilean and Argentine reluctance to agree to international control. However, the advisability of maintaining the Antarctic free for the kinds of scientific observations and studies begun during the IGY ultimately prevailed. A formal treaty conference was opened on October 15, 1959, and the treaty was signed on December 1, 1959. On August 4, 1960, Japan became the first nation to ratify the treaty, at that time considered "unique in diplomatic history."[226] U.S. ratification followed on August 18, 1960, and the treaty entered into force for the United States on June 23, 1961. Major provisions of the treaty are as follows:

Article 1. Antarctica shall be used for peaceful purposes only. All measures of a military nature, including weapons testing, are prohibited.
Article 2. Freedom of scientific investigation and cooperation shall continue.
Article 3. Scientific plans, personnel, observations, and results shall be freely exchanged.
Article 4. Signatories do not recognize, dispute, or establish territorial claims.
Article 5. Nuclear explosions and the disposal of radioactive wastes in the area are prohibited.
Article 6. All land and ice masses below 60 degrees south latitude are included, but international law with regard to the high seas shall prevail.
Article 7. Observers from treaty nations have the right of free access to any area and may inspect all stations, installations, and equipment within those areas. Aerial observations are permitted, and each signatory must provide advance notice of its activities within the area.[227]

THE TEST BAN TREATY

The spirit of international cooperation and good will resulting from the IGY, and the communication channels thereby opened up among nations, may have played an appreciable part in negotiations which led to the Test Ban Treaty.[228] It would be difficult to overestimate the role of communications in international affairs, especially since technical talks appear to have become an accepted approach to difficult international problems. Lloyd Berkner, in addressing the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, in Geneva, had emphasized the value of the experience gained during the IGY. Sullivan pointed out that "The IGY had helped significantly to contribute to the atmosphere of international scientific cooperation in which the Geneva talks were held," [229] and U.N. Secretary General Dag Hammarskjold, in his Annual Report to the United Nations General Assembly, had noted that "the Geneva agreement suggested a way by which further progress might be made in separating the political from the nonpolitical." Hammarskjold went on to point out that discussion by scientists

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[225] Sullivan, "The IGY," p. 325. Participating nations, in addition to the United States, were: Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, the Soviet Union, the Union of South Africa, and the United Kingdom.

[226] Neal Stanford. "Antarctica: Where Territorial Claims Are Barred," *The Christian Science Monitor*, Jan. 9, 1971, p. 5.

[227] Summarized from: Department of State, *Treaties and Other International Acts Series*, No. 4780 (Washington: U.S. Government Printing Office, 1961), 36 pages. The Antarctic Treaty, in banning nuclear explosions from the Antarctic, established a precedent for what was to become a steadily expanding concept of "nuclear free zones" throughout the world. One such proposal would have progressively moved the area covered by the Antarctic Treaty to further latitudes. Other proposals would have expanded the concept to include Latin America, Asia, Africa, and Western Europe. To the extent that such proposals represent additional efforts to achieve diplomatic agreement, they owe much to the spirit of international cooperative good will that evolved from the IGY.

[228] Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water. State Department Document TIAS No. 5433.

> . . . would not in itself bring about disarmament, but it might help to improve the atmosphere and clarify many of the problems involved, thus preparing the ground for a time more politically propitious than the present seems to be for a general disarmament agreement.[230]

Although it is too soon to judge its significance, the Test Ban Treaty appears to have been a critical forward step toward the responsible international control of arms in the interest of world peace and security. President Kennedy is said to have attached great importance to the treaty as a symbol which

> . . . would provide a turning point, a way to break out of the circle of fear, distrust, conflict, insistence on strength, demands for guarantees, insistence on the unchanging and implacable hostility and activist role of the Soviet Union, and the futile search by the United States to bring back the total security of the preatomic period.[231]

To a considerable extent, the President's attitude thus was in close agreement with the political expectations raised by scientists during the IGY. It seems a fair assumption that at least some aspects of the IGY experience were translated into political attitudes and behavior which ultimately led to the Test Ban Treaty.

The treaty was signed in Moscow on August 5, 1963, received Senate approval on September 24, was signed by President Kennedy on October 7, and entered into force for the United States on October 10. In article I of the treaty, each signatory agreed to prohibit all nuclear explosions on territory within its jurisdiction and control, including tests of nuclear weapons, in the atmosphere or under water. This prohibition also encompassed outer space and the high seas. Nuclear explosions were prohibited in any environment whatsoever if they might result in the presence of radioactive debris outside the territorial limits of the nation conducting the explosion. Furthermore, signatories agreed to refrain from offering help or encouragement for any nuclear weapons tests whatsoever within the prohibited environments.[232]

These provisions bear a resemblance to article I of the Antarctic Treaty banning "the testing of any type of weapons." It is clear from congressional hearings and debates on the Test Ban Treaty that the IGY experience and the Antarctic Treaty were prominent in the thoughts of many participants. Reference was made to the fact that the Antarctic Treaty had been in force for almost 5 years without incident, and the debate prompted the first formal inspections to be carried out under article VII of the treaty.

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[229] Sullivan, "The IGY," p. 334.

[230] United Nations General Assembly, *Official Records*, 13th sess., 1958, supp. No. 1A, p. 1.

[231] U.S., Congress, House, Committee on Science and Astronautics, Subcommittee on Science, Research, and Development, *Technical Information for Congress*, 92d Cong., 1st sess., Apr. 15, 1971 (revised edition), p. 238.

[232] Department of State, *Treaties and Other International Acts Series*, No. 5433 (Washington: U.S. Government Printing Office, 1963), 75 pp.

THE SPACE TREATY

The need for future cooperation in space was already evident at the time the Antarctic Treaty [233] was signed. As discussed by Sullivan,

> Before putting their pens to [the Antarctic Treaty] several of the signers pointed out that, contingent upon the treaty's ratification, it could serve as a precedent for the settlement of the more difficult problem of outer space. [234]

As early as March 15, 1958, while the IGY was still in progress, the Soviet Government had proposed an international agreement "for cooperation in the exploration and peaceful use of outer space," and had referred the question to the United Nations for consideration.[235] In the fall of 1958, when the General Assembly convened for its 13th session, the Soviet resolution was debated along with a similar resolution proposed by the United States on September 2, 1958.[236] The primary difference between the two proposals was that the Soviet resolution incorporated the question of removal of military bases from foreign soil, whereas the American resolution did not. Subsequently, a compromise resolution was introduced on November 13, 1958, by 20 nations, including the United States, entitled "Question of the Peaceful Uses of Outer Space," which was adopted by the General Assembly on December 13, 1958.[237] Incorporated in this resolution were two specific references to the IGY. In the preamble, the resolution called to attention the fact that the General Assembly noted

> . . . the success of the scientific cooperative program of the International Geophysical Year in the exploration of outer space and the decision to continue and expand this type of cooperation . . . .

The resolution then established the Ad Hoc Committee on the Peaceful Uses of Outer Space to report to the General Assembly on the

> . . . continuation on a permanent basis of the outer space research now being carried on within the framework on the International Geophysical Year.[238]

Difficulties were encountered, however, with the space treaty itself. The United States was willing and made ". . . numerous gestures in an effort to elicit Soviet participation in cooperative space activities, but to no avail." [239] On the surface, the Soviets clearly supported the principle of international cooperation, citing their participation in the IGY, and giving "special emphasis to the need for international cooperation in space exploration." [240] In practice, however, the Soviets appeared to be less candid. The years immediately following the IGY represented " a period of acute international distress," with Soviet policy becoming "confidently outgoing, aggressively assertive, and dangerously risk taking." [241] As a consequence, the Soviets were professing one course of action while following another. This behavior was aptly described by Frutkin:

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[233] "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies" (State Department Document TIAS 6347). Furthermore, in like manner, the IGY can be considered as having played a similar role in the more recent Agreement on the Rescue of Astronauts and the Return of Objects Launched Into Outer Space (signed on Apr. 22, 1968, and entered into force for the United States on Dec. 3, 1968; see State Department Document TIAS 6599); and the Convention on International Liability for Damage Caused by Space Objects (signed on Mar. 29, 1972, and entered into force on Sept. 1, 1972).

[234] Sullivan, *Assault*, p. 415.

[235] U.S., Congress, Senate, Committee on Aeronautical and Space Sciences, *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies. Analysis and Background Data*, 90th Cong., 1st sess., March 1967, p. 5.

[236] S. Doc. No. 56, *International Cooperation and Organization*, p. 184.

[237] S. Doc. No. 56, *International Cooperation and Organization*, p. 185.

[238] S. Doc. No. 56, *International Cooperation and Organization*, p. 186.

[239] Senate, *Soviet Space Programs, 1962–65*, p. 428.

[240] Senate, *Soviet Space Programs: Organization*, [*etc.*], pp. 173–174. In particular, V. V. Kuznetsov expounded on this point in a speech before the 14th General Assembly; see "Unanimity in Outer Space," *United Nations Review* 6 (February 1960), p. 34. Later, on Sept. 20, 1963, in a speech before the Assembly, President Kennedy called for the United States and the U.S.S.R. to join forces in exploring outer space. In particular, the President called for both nations to cooperate in a manned lunar landing: "Why . . . should man's first flight to the Moon be a matter of national competition? . . . Surely we should explore whether the scientists and astronauts of our two countries—indeed, of all the world—cannot work together in the conquest of space, sending someday in this decade to the Moon not the representatives of a single nation but the representatives of all of our countries" *Department of State Bulletin* 45 (Oct. 7, 1963), pp. 532–533.

> The Russians have accepted such cooperation in principle, and have suggested a cautious step-by-step procedure. But we have not yet been able to identify the first step.[242]

Not until December 20, 1961, did "a breakthrough in the politics of space cooperation" seem to take place with the adoption of the United Nations General Assembly Resolution 1721 (XVI), which cleared the way for initiation of a "comprehensive program of space cooperation under the auspices . . . of the United Nations." [243] Progress was such that by 1965 Frutkin was able to write,

> Soviet attitudes and performance, and, indeed, personal relationships with their representatives, all have come a long way since the early days of the International Geophysical Year.[244]

By 1973 American-Soviet relations had improved so remarkably that Frutkin could comment that collaboration between members of the joint working groups of the Apollo-Soyuz Test Project was "unmatched" in their experience.[245]

Provisions of the Space Treaty, which was signed on January 27, 1967 and entered into force for the United States on October 10, 1967, bore marked similarities to principles established earlier by the Antarctic Treaty. Major provisions were as follows:

Article 1. The exploration and use of outer space shall be for the benefit of all nations. There shall be access to all areas, including celestial bodies, for exploration and scientific investigation.
Article 2. Outer space, including the moon and other celestial bodies, shall not be subject to claims of sovereignity by any nation regardless of use or occupation.
Article 3. International law shall prevail in outer space.
Article 4. Outer space, including the moon and other celestial bodies, shall be used for peaceful purposes. All measures of a military nature, including the presence of nuclear weapons in outer space, are prohibited.
Article 5. Signatories shall treat astronauts as envoys of mankind, rendering all possible assistance in the event of accidents or emergencies, and shall inform one another of all dangers to human life and health.
Article 6. Signatories shall bear the responsibility for their activities in outer space.
Article 7. Signatories shall bear responsibility for all damage caused by launching of objects into outer space.
Article 8. Signatories shall maintain individual ownership of all objects launched into outer space.
Article 9. Signatories shall not conduct activities in outer space which may prove harmful to other nations.

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[241] Senate, *Soviet Space Programs, 1962-65*, p. 427. The report goes on to state that "Khrushchev seemed to be concerned less with cooperating in space than with making a concrete political reality of the abstract Soviet claim that a shift in the balance of world power against the West had occurred, and that this was attributed, among other factors, to Communist superiority."

[242] Senate, *Soviet Space Programs: Organization,* [*etc.*], p. 176. Speech to the Phi Beta Kappa alumni of New York City on Mar. 15, 1961. Frutkin was referring to Soviet cooperation during the IGY itself, stating that "the Soviet voice was often raised to limit the scope of exchange agreements" (Senate, *Soviet Space Programs, 1962-65*, p. 443). In retrospect, however, his remarks appear more appropriate to the immediate post-IGY period under discussion above.

[243] Senate, *Soviet Space Programs, 1966-70*, p. 399. For further detail, see: Senate, *Soviet Space Programs, 1962-65*, p. 427.

[244] Senate, *Soviet Space Programs, 1966-70*, p. 452.

[245] Senate, *Hearings on S. 880*, p. 1368.

Article 10. Signatories shall consider on a basis of equality any requests by other signatories to observe the flight of objects launched into outer space.
Article 11. Signatories shall make public the nature, conduct, location, and results of their activities in outer space to the fullest extent feasible and practicable.
Article 12. All stations, installations, equipment, and space vehicles on the moon and other celestial bodies of each signatory shall be open to representatives of all other signatories.[246]

Six of the basic concepts of the 7 major articles of the Antarctic Treaty are included within the 12 articles of the Space Treaty, as shown in table 6.

TABLE 6. COMPARISON OF THE PROVISIONS OF THE ANTARCTIC AND SPACE TREATIES

Antarctic Treaty Provision	Space Treaty
Art. 1. Peaceful use, ban on military activities	Art. 4.
Art. 2. Freedom of scientific investigation	Art. 1.
Art. 3. Free exchange of information	Art. 11.
Art. 4. No recognition of territorial claims	Art. 2.
Art. 5. Ban on nuclear explosions	
Art. 6. Validity of international law	Art. 3.
Art. 7. Free right of inspection	Art. 12.

Article 5 of the Antarctic Treaty, prohibiting the carrying out of nuclear explosions, was unnecessary in the Space Treaty in view of the previous signing of the Test Ban Treaty. Arthur Goldberg, in his capacity as U.S. Representative to the U.N. General Assembly, remarked that the arms control provision of the Space Treaty ". . . is similar to that embodied in the Antarctic Treaty . . . namely, free access by all parties to one another's installations." [247]

This free access principle, as well as other basic principles established by the Antarctic Treaty, could be applied to outer space largely because, as during the IGY,

> . . . no nation protested the flight of satellites over its territory. No nation requested the launching states to obtain permission to fly over its sovereign lands and territorial waters . . . No nation reserved its rights with regard to spaceflights in the future. Nor did any nation set an upper limit on airspace that might have been construed as the lower boundary for outer space.[248]

Thus, as pointed out by Ambassador Goldberg, the three treaties represented a "historic progression":

> First was the Antarctic Treaty of 1959, reserving that large area of the world for exclusively peaceful activity; second was the limited test ban treaty of 1963, and third is the treaty [on outer space] which now lies before this committee.[249]

Concluding Remarks

As indicated earlier, the main objective of this case study has been to shed light on whether the good will and cooperative spirit generated by the international scientific community can be utilized to any extent in the international political arena. In particular, the objective was to determine whether the unprecedented scientific legacy of the IGY exerted any significant impact upon subsequent international political behavior.

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[246] Summarized from: Department of State, *Treaties and Other International Acts Series*, No. 6347 (Washington: U.S. Government Printing Office, 1967), 89 pp.

[247] *Department of State Bulletin 49* (Jan. 9, 1967), p. 80. From a speech before the U.N. General Assembly. Goldberg was referring specifically to art. I, II, and XII of the treaty.

[248] Eilene Galloway, "Law, Order, and Outer Space," *Electronic Age 29* (autumn 1970), p. 4.

[249] *Department of State Bulletin 49* (Jan. 9, 1967), p. 78. Goldberg mentioned this "historic progression" twice during his remarks.

It would appear that this question can now be answered affirmatively. The evidence is highly suggestive, if not conclusive, that the new communications channels, the tremendous cooperative spirit, and the increased understanding among participants of the 67 nations which took part in the IGY led directly to the Antarctic Treaty. Whether or not the IGY can be credited in such strong terms, it clearly played an important part in helping shape that treaty, which in turn reinforced the cooperative pattern for the other treaties and agreements which were to follow. Just as scientists approach their objectives through a step-by-step process, so did politicians appear to approach these international objectives in similar fashion, with similar success.

It may be argued, of course, that the implications of the Cuban missile crisis of 1962 had more to do with the test ban than did the IGY, that only after facing up to the unpleasant realities of a possible nuclear war did the Soviets opt for agreement, thereby making possible the essential conditions in which the promise of the IGY could be fulfilled. To acknowledge the reality of political and military power, however, is not to diminish the power of the IGY as an idea whose time had come.

Perhaps an even more persuasive testament to that power is to be found not in the symbolic, formal language and protocol of treaties but in the quickened pace and broadened scope of the many international meetings to exchange both basic knowledge and technological know-how which can trace their origins to the IGY example. It was 50 years between the First Polar Year and the Second, and 25 years from that to the IGY. Today hardly a year goes by without one or more major conferences addressed to phenomena and problems of the environment, the oceans, energy, or new aspects of mankind's relationships with regard to outer space. To say that the IGY was responsible for these developments to advance the human condition would be gross overstatement, since the phenomena and problems themselves are ultimately responsible simply by their existence. But human perception of them was furthered by the IGY; international good will in collaborating to explore them was fostered by it; and it seems quite possible that the IGY conferred on political leaders of most of the world's nations an enlarged appreciation of the potential of constructive international collaboration for solving political, as well as scientific and technological, problems.

APPENDIX 1. LIST OF ABBREVIATIONS

ACIGY	Advisory Council of the International Geophysical Year.
CCIR	International Radio Consultative Committee.
CETX	Inter-Union Committee on Contamination by Extra-Terrestrial Exploration.
CIG	Comité Internationale de Geophysique (International Geophysical Committee).
COMSAT	Communications Satellite Corporation.
COSPAR	Committee on Space Research.
CSAGI	Bureau du Comité Special de l'Année Géophysique Internationale 1957–58 (Special Committee for the International Geophysical Year).
FAGS	Federation of Astronomical and Geophysical Services.
FPY	First International Polar Year.
IATME	International Association of Terrestrial Magnetism and Electricity.
IAU	International Astronomical Union.
ICSU	International Council of Scientific Unions.
IGU	International Geographical Union.
IGY	International Geophysical Year.
IMU	International Mathematical Union.
INTELSAT	International Telecommunications Satellite Consortium.
IUB	International Union of Biochemistry.
IUBS	International Union of Biological Sciences.
IUCr	International Union of Crystallography.
IUGG	International Union of Geodesy and Geophysics.
IUHPS	International Union of History and Philosophy of Science.
IUPAC	International Union of Pure and Applied Chemistry.
IUPAP	International Union of Pure and Applied Physics.
IUPS	International Union of Physiological Sciences.
IUTAM	International Union of Theoretical and Applied Mechanics.
IWDS	International World Days Service.
MCI	Mixed Commission on the Ionosphere (or, Joint Commission on the Ionosphere).
NSF	National Science Foundation.
SCAR	Special Committee on Antarctic Research.
SCG	Special Committee for Inter-Union Cooperation in Geophysics.
SCOR	Special Committee on Oceanic Research.
SPY	Second International Polar Year.
TPY	Third International Polar Year.
UNESCO	United Nations Educational, Scientific, and Cultural Organization.
URSI	Union Radio-Scientifique Internationale (International Scientific Radio Union).
USNC–IGY	United States National Committee for the IGY.
WMA	World Meteorological Association.
WMO	World Meteorological Organization.

Appendix 2. A Brief Chronology of the IGY

Aug. 1, 1882	Beginning of the First International Polar Year.
Aug. 31, 1883	End of the First International Polar Year.
Aug. 1, 1932	Beginning of the Second International Polar Year.
Aug. 31, 1933	End of the Second International Polar Year.
April 5, 1950	Berkner's proposal for a Third Polar Year, at a meeting in Van Allen's home.
July 1950	Meeting of the MCI at which it was decided to commend the Berkner proposal to the ICSU and its unions.
Sept. 1950	Approval of the Berkner proposal by URSI.
Sept. 1950	Approval of the Berkner proposal by IAU.
Jan. 1951	ICSU Bureau commends the Berkner proposal to its Executive Board.
Aug. 1951	Approval of the Berkner proposal by the IUGG.
Oct. 1951	Creation by the ICSU of a Special Committee for a Third International Polar Year.
Oct. 1952	Suggestion by Chapman that the name be changed to International Geophysical Year approved by ICSU.
Oct. 1952	Provisional meeting of the CSAGI; all nations are asked to form national IGY committees.
June 30–July 3, 1953	First plenary session of CSAGI in Brussels, attended by 26 nations.
Early 1954	Program devised for world days and 10-day meteorological intervals.
March 1954	Completion of proposed IGY program by the USNC.
May 1954	Deadline for submission of detailed national programs.
Sept. 30–Oct. 4, 1954	Second plenary session of the CSAGI in Rome, attended by 38 nations.
March 1955	Recommendation by ICSU that an Advisory Council be formed to assist CSAGI.
Sept. 8–14, 1955	Third plenary session of the CSAGI in Brussells. Parallel sessions of the Advisory Council. Decision was made that the IGY be officially begun at zero hours, Greenwich time, on July 1, 1957.
Sept. 10–15, 1946	Fourth plenary session of the ICSU in Barcelona.
Jan. 10, 1957	Creation by the U.S.S.R. of the "Consultative Committee for Preparing for and Implementing the IGY at Establishments of the Academy of Sciences, U.S.S.R."
July 1, 1957	Official beginning of the IGY at zero hours Greenwich time.
Oct. 4, 1957	Sputnik I injected into orbit to become the world's first artificial earth satellite.
July 29–Aug. 9, 1958	Final plenary session of the CSAGI in Moscow.
Dec. 31, 1958	Official end of the IGY.